Fig. 1

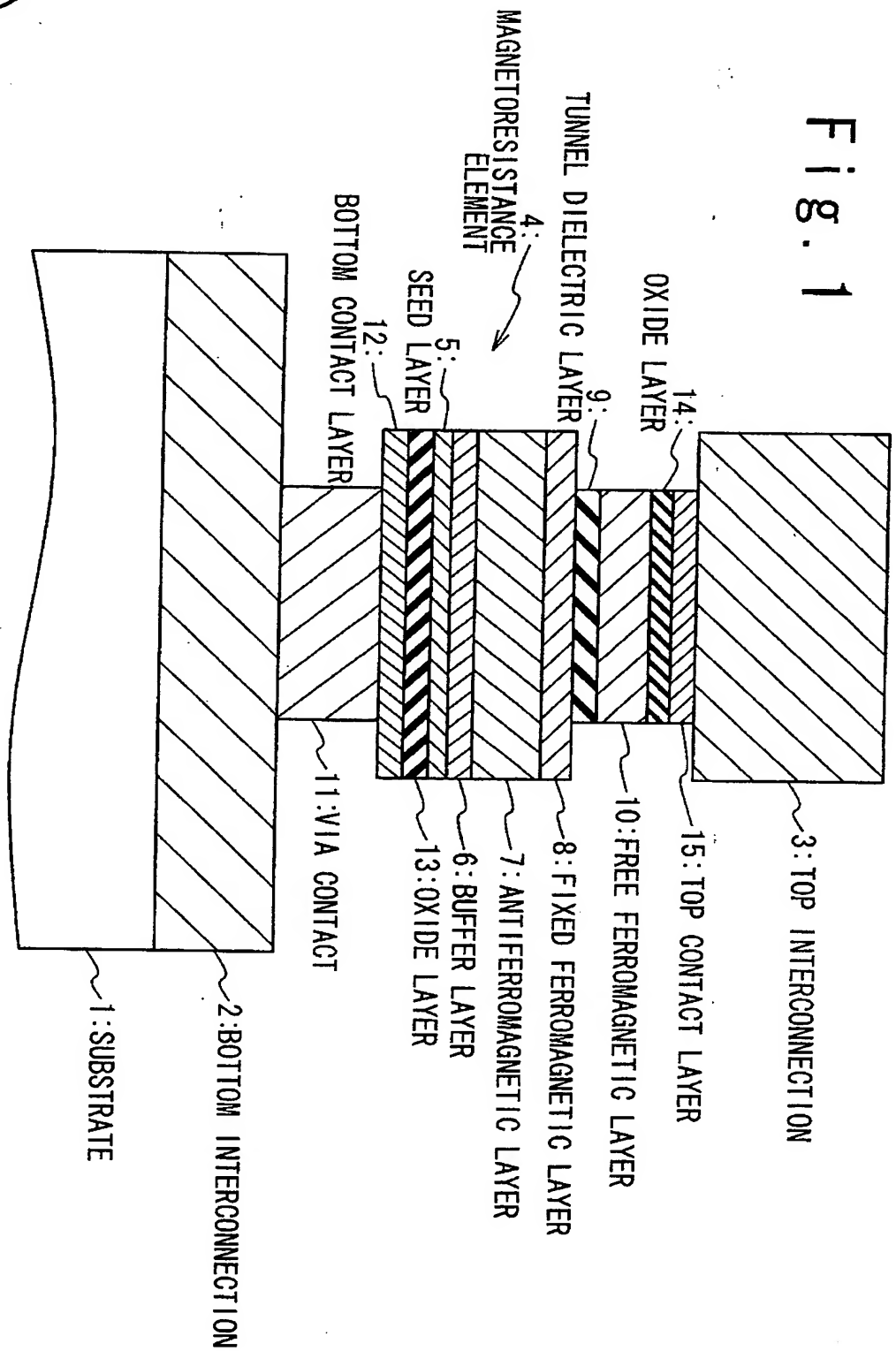


Fig. 2

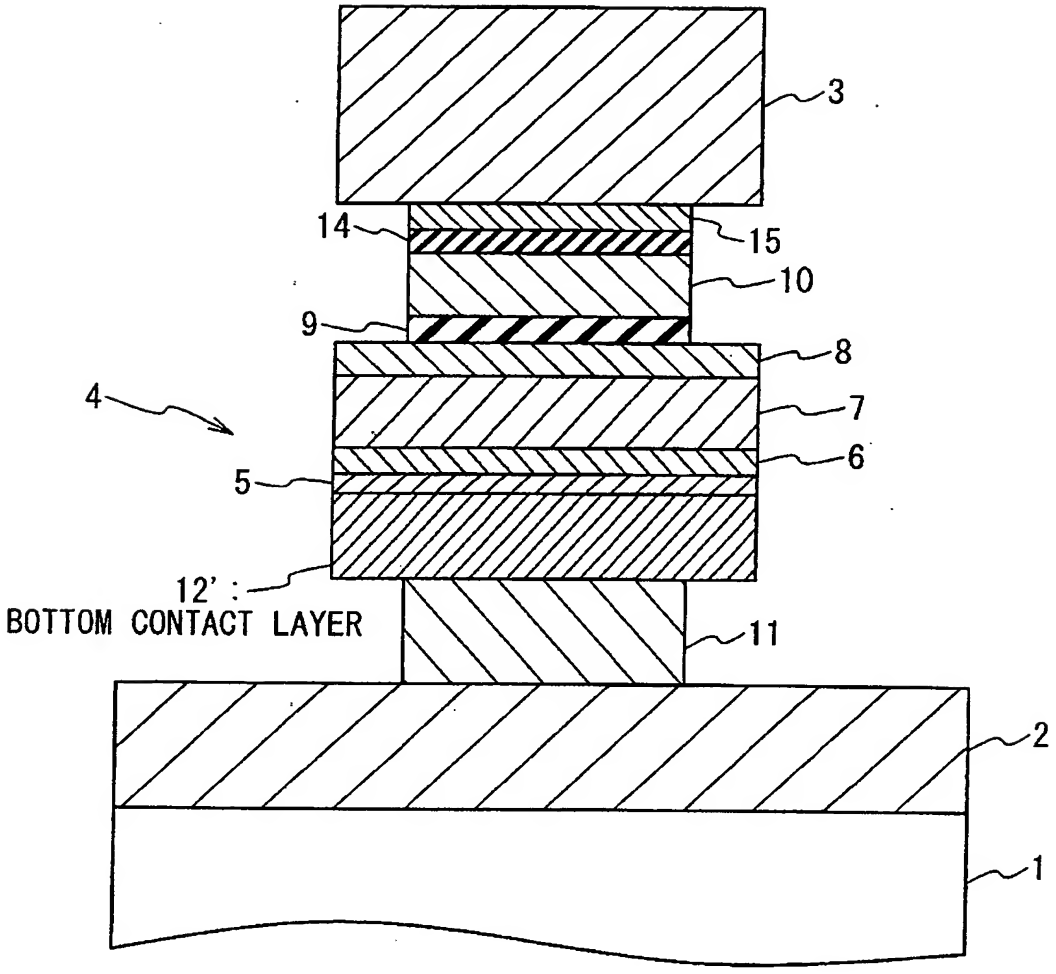
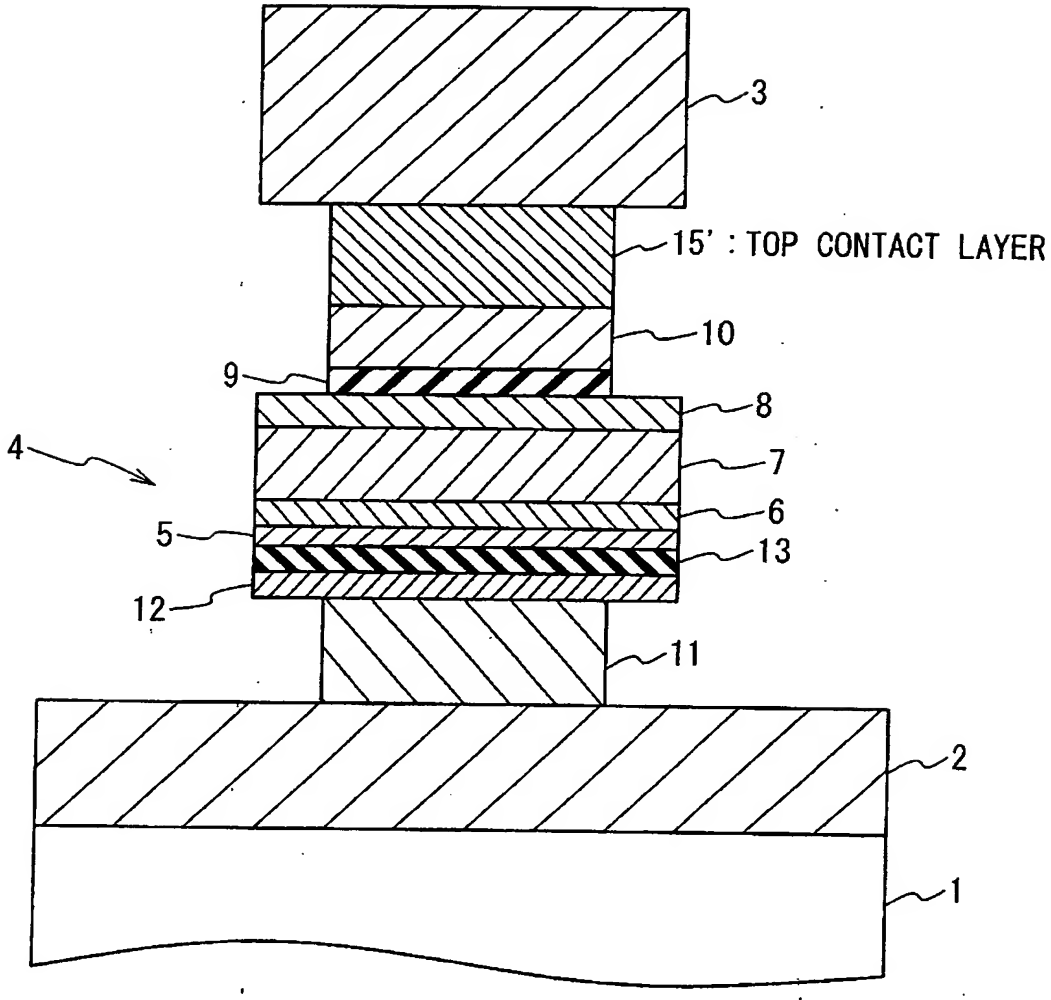


Fig. 3



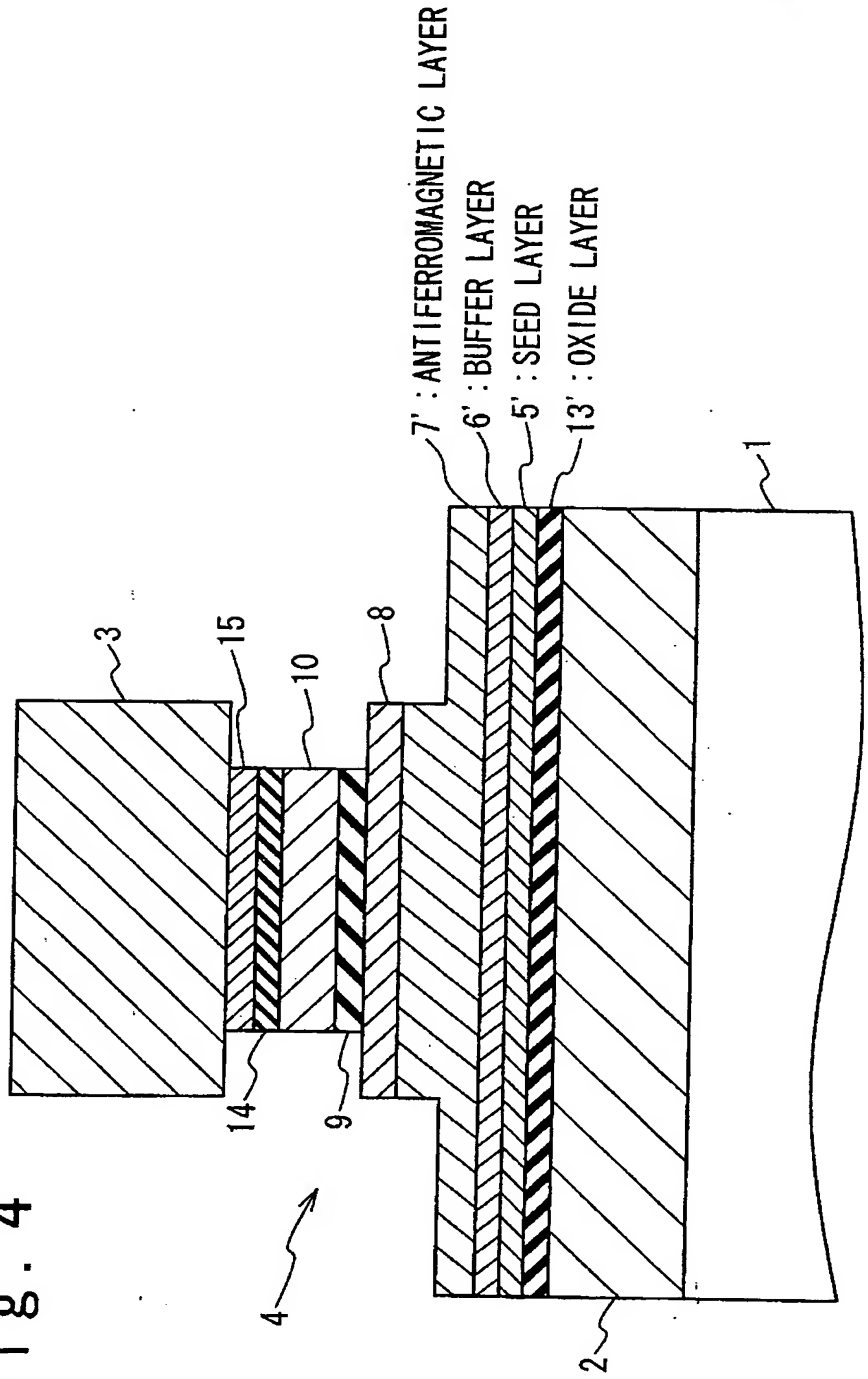

7' : ANTIFERROMAGNETIC LAYER
6' : BUFFER LAYER
5' : SEED LAYER
13' : OXIDE LAYER
1
3
15
10
8
14
9
4
2

Fig. 4

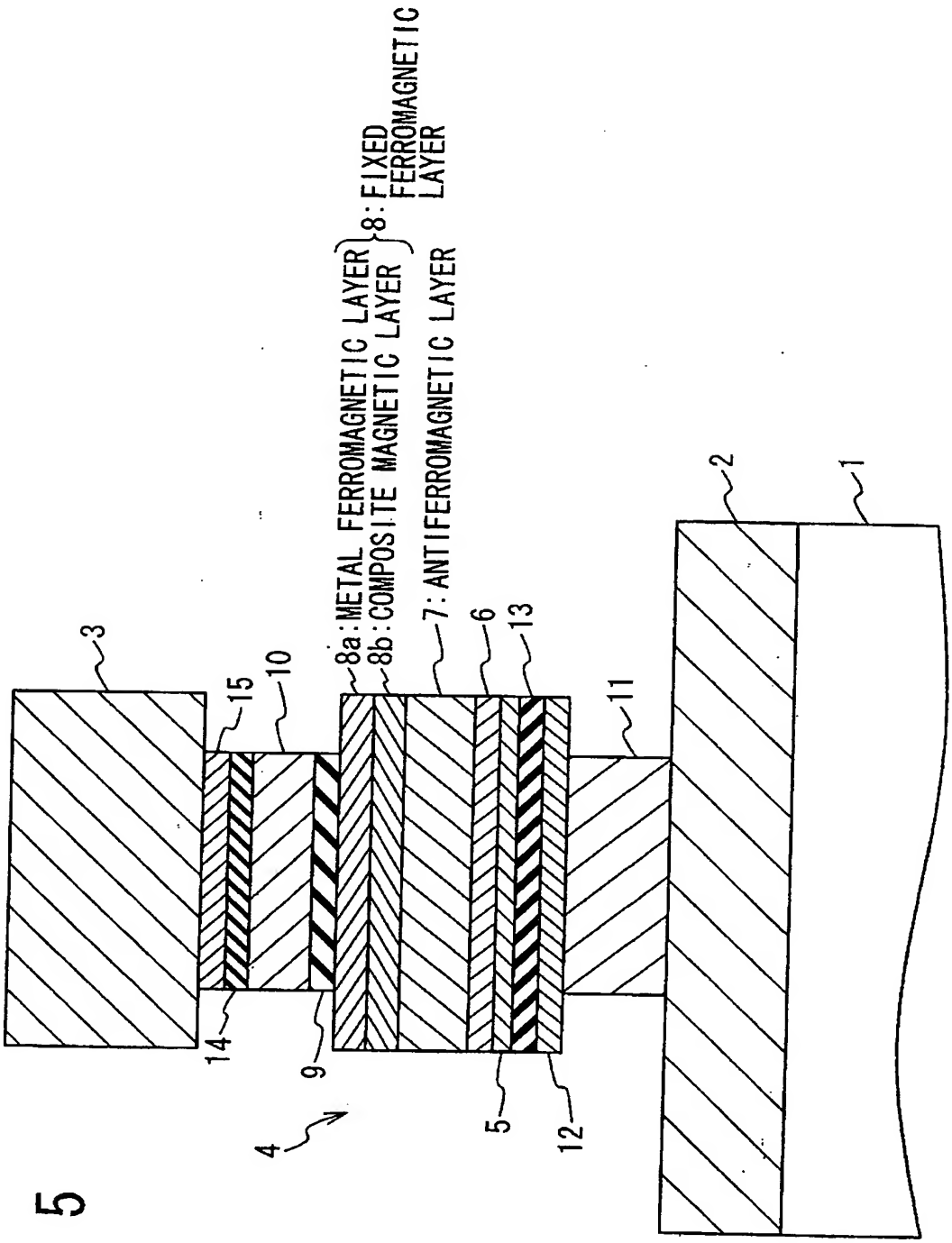

8: FIXED FERROMAGNETIC LAYER
8a: METAL FERROMAGNETIC LAYER
8b: COMPOSITE MAGNETIC LAYER
7: ANTIFERROMAGNETIC LAYER
1
2
3
4
5
6
9
10
11
12
13
14
15

Fig. 5

Fig. 6A

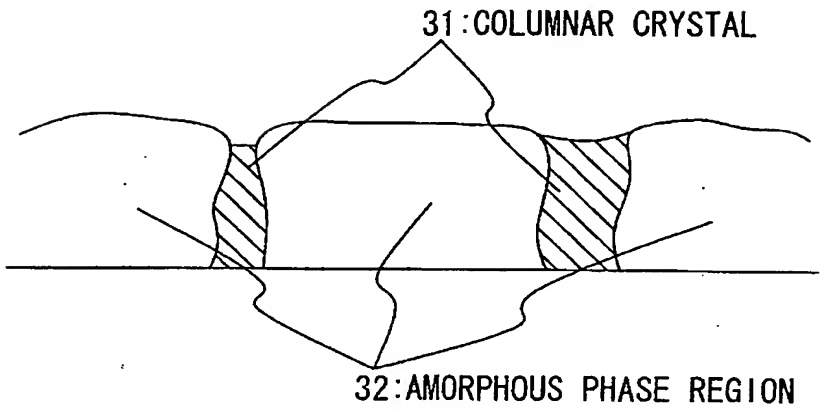

31:COLUMNAR CRYSTAL
32:AMORPHOUS PHASE REGION

Fig. 6B

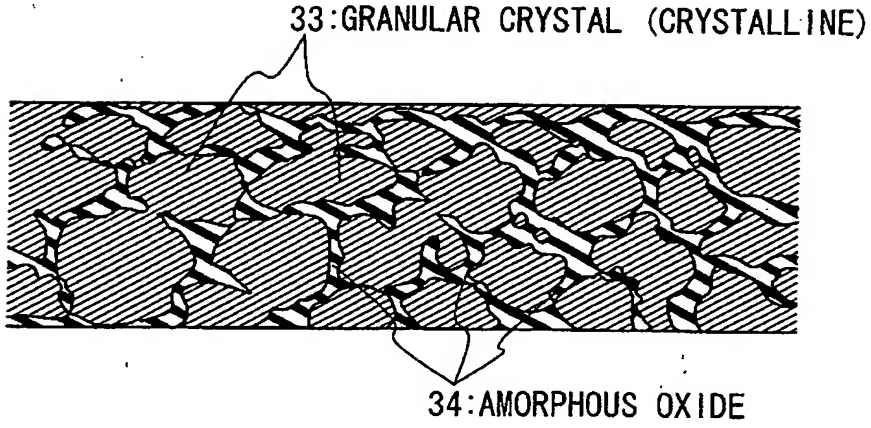

33:GRANULAR CRYSTAL (CRYSTALLINE)
34:AMORPHOUS OXIDE

Fig. 7

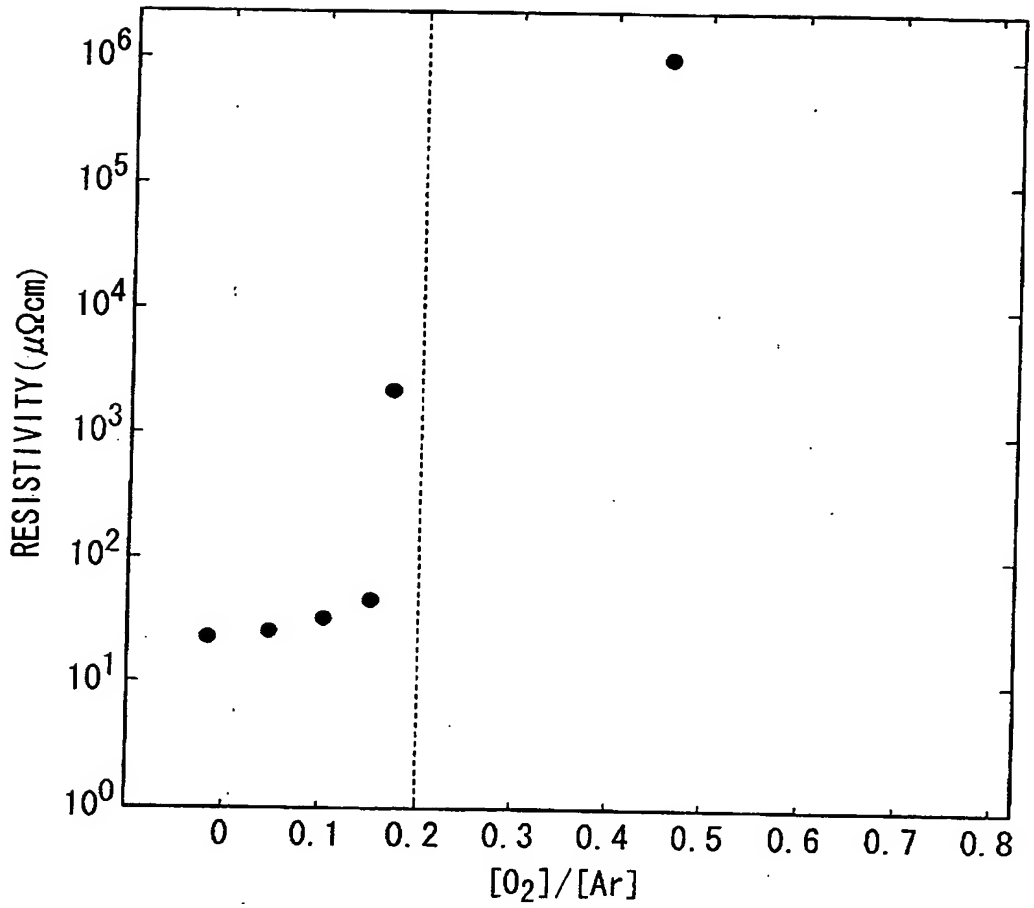

RESISTIVITY (μΩcm)
10^6
10^5
10^4
10^3
10^2
10^1
10^0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
[O2]/[Ar]

Fig. 8

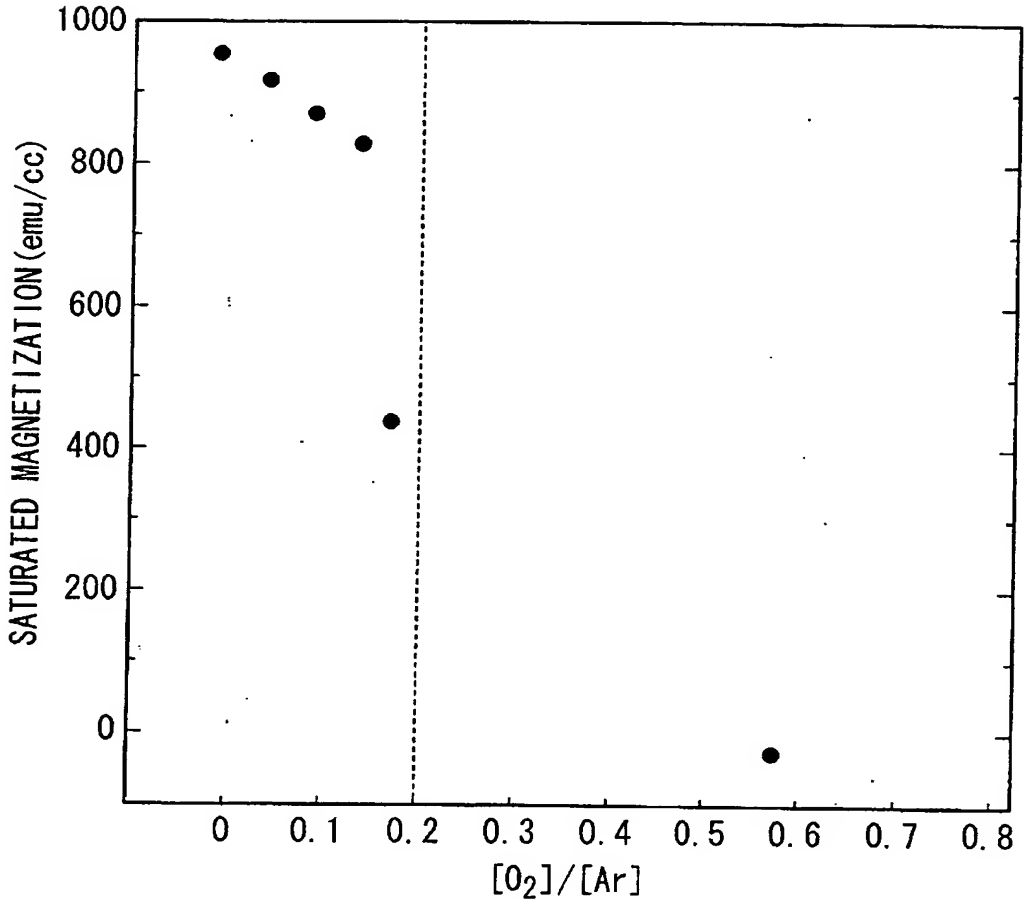

1000
800
600
400
200
0
SATURATED MAGNETIZATION (emu/cc)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
[O2]/[Ar]

Fig. 9

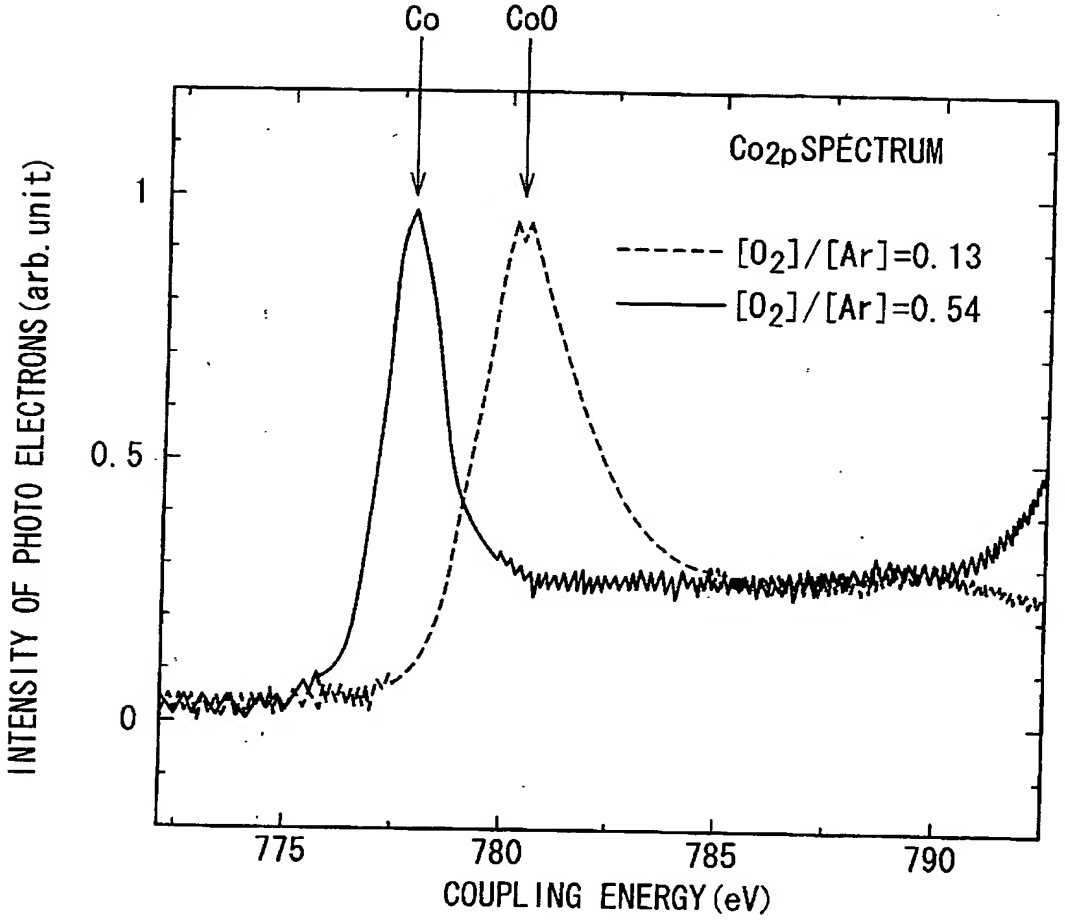

Co
CoO
Co2p SPECTRUM
[O2]/[Ar]=0.13
[O2]/[Ar]=0.54
INTENSITY OF PHOTO ELECTRONS (arb. unit)
1
0.5
0
775
780
785
790
COUPLING ENERGY (eV)

Fig. 10

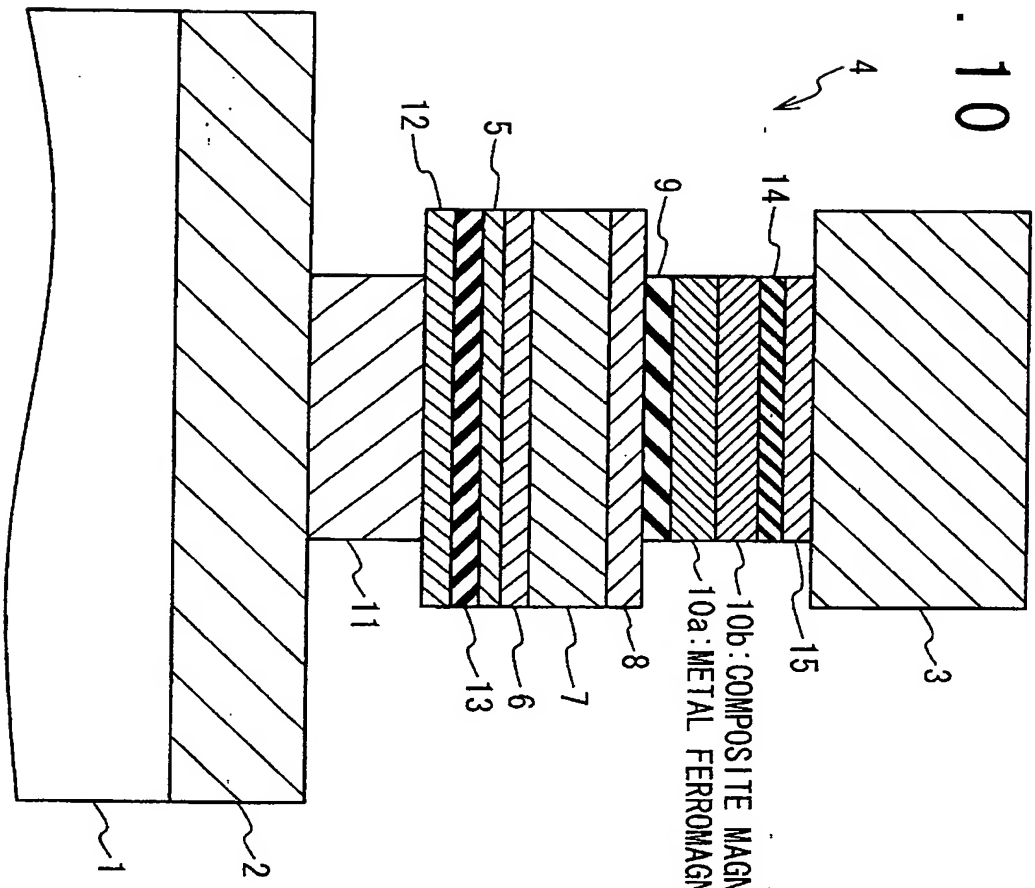

4
12
5
9
14
1
2
11
13
6
7
8
15
3
10b:COMPOSITE MAGNETIC LAYER
10a:METAL FERROMAGNETIC LAYER
10:FREE FERROMAGNETIC LAYER

Fig. 11

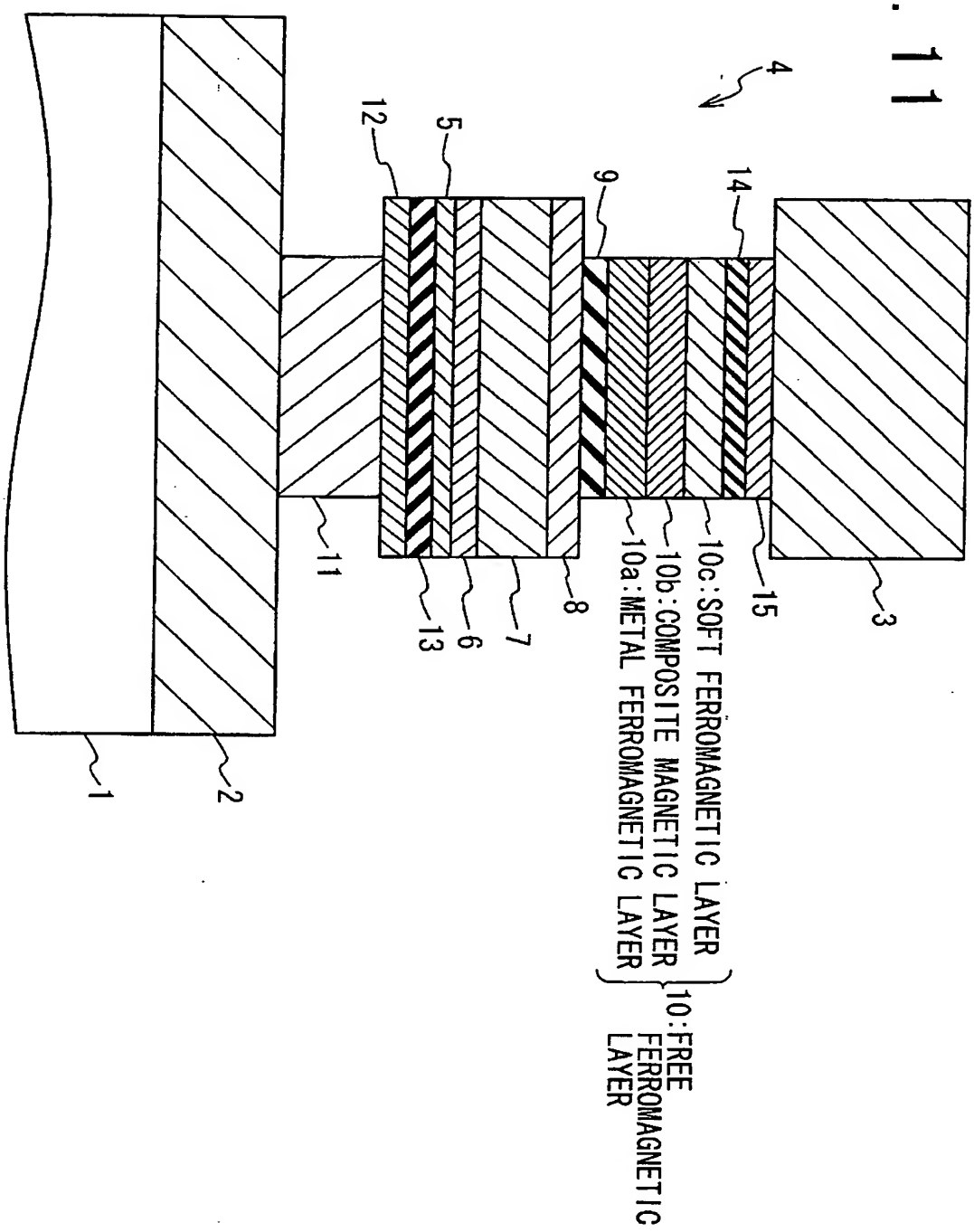

4
12
5
9
14
1
2
11
13
6
7
8
15
3
10c:SOFT FERROMAGNETIC LAYER
10b:COMPOSITE MAGNETIC LAYER
10a:METAL FERROMAGNETIC LAYER
10:FREE FERROMAGNETIC LAYER

Fig. 12

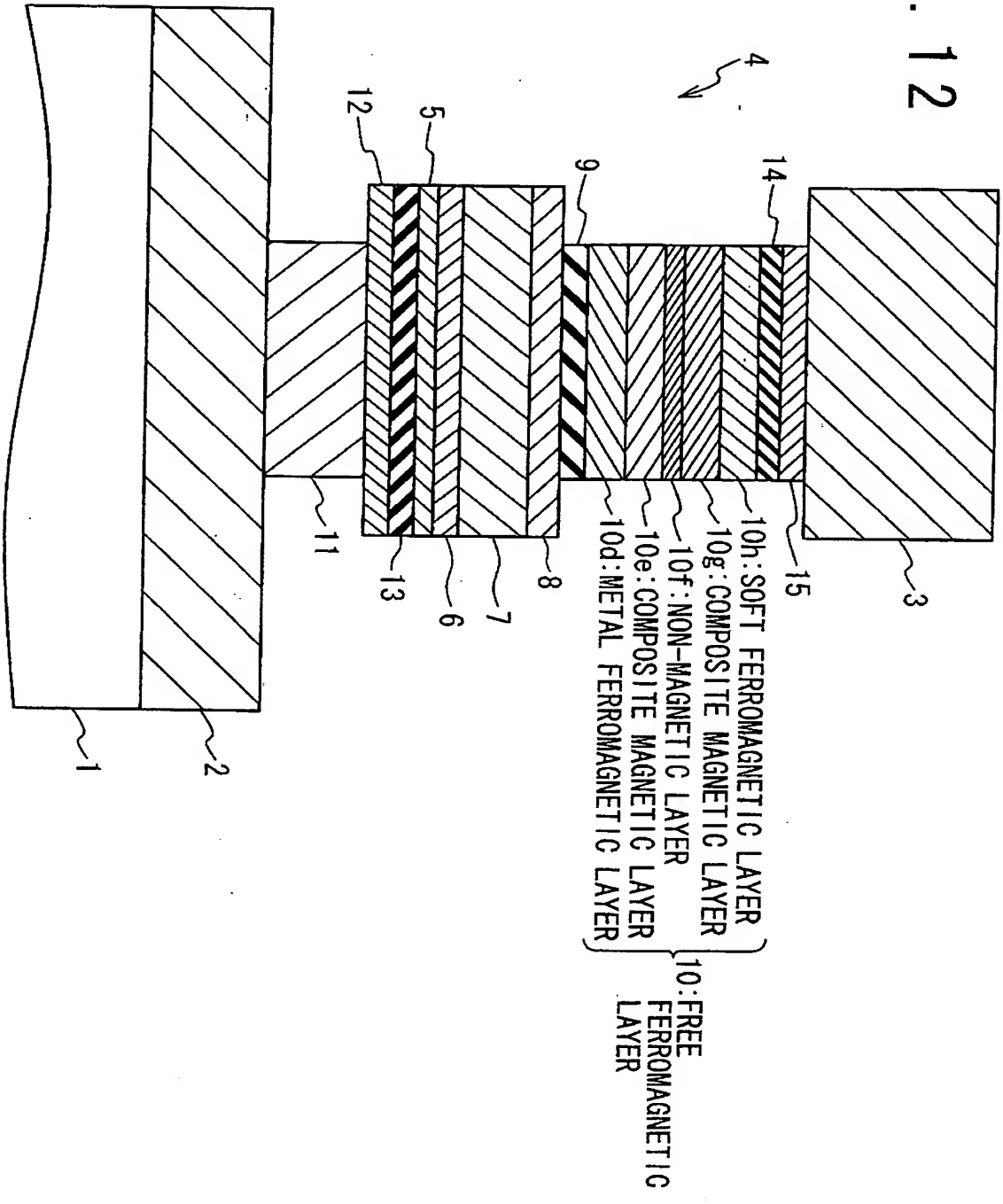

4
12
5
9
14
1
2
11
13
6
7
8
15
3
10h:SOFT FERROMAGNETIC LAYER
10g:COMPOSITE MAGNETIC LAYER
10f:NON-MAGNETIC LAYER
10e:COMPOSITE MAGNETIC LAYER
10d:METAL FERROMAGNETIC LAYER
10:FREE FERROMAGNETIC LAYER

Fig. 13

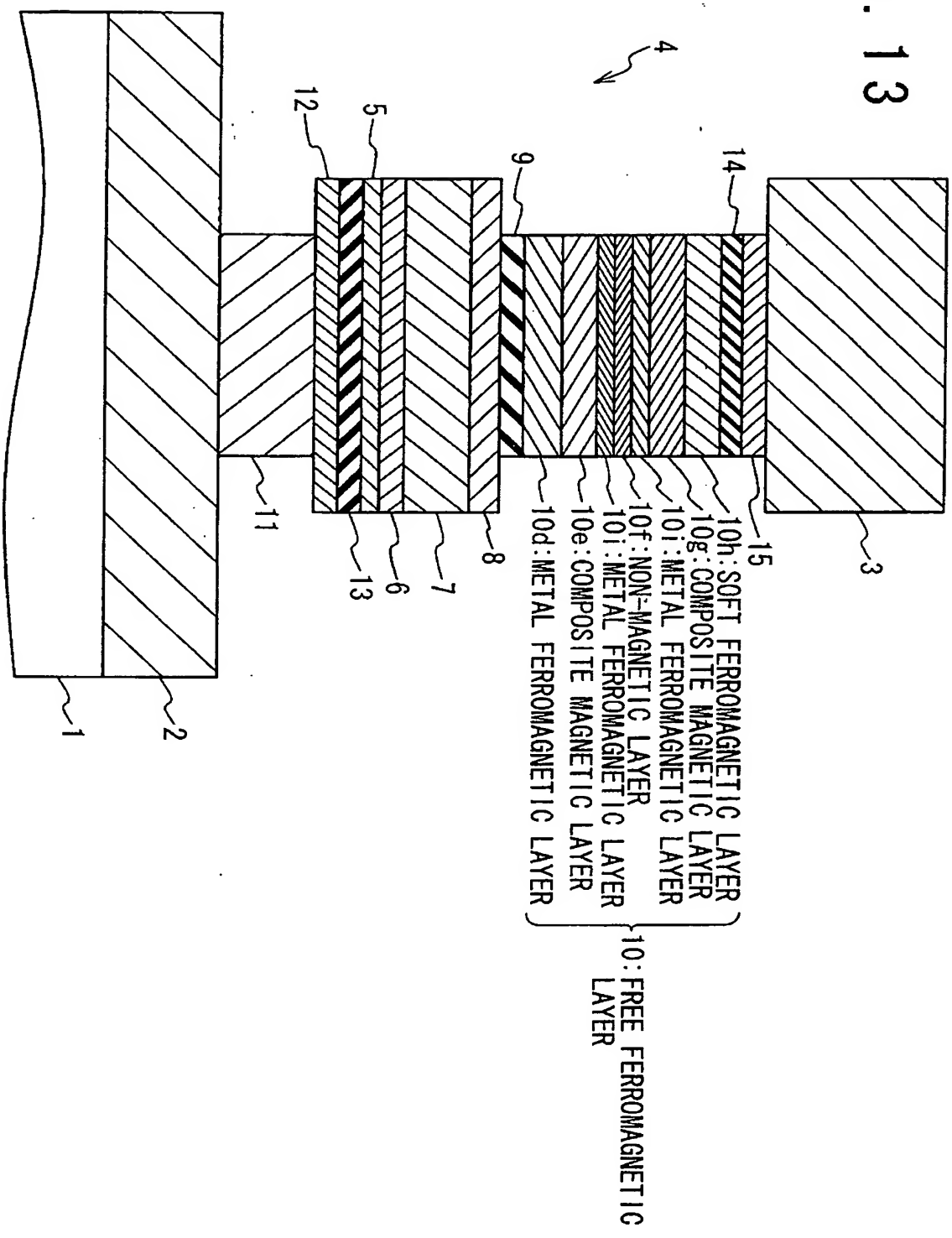

4
12
5
9
14
1
2
11
13
6
7
8
15
3
10h:SOFT FERROMAGNETIC LAYER
10g:COMPOSITE MAGNETIC LAYER
10i:METAL FERROMAGNETIC LAYER
10f:NON-MAGNETIC LAYER
10i:METAL FERROMAGNETIC LAYER
10e:COMPOSITE MAGNETIC LAYER
10d:METAL FERROMAGNETIC LAYER
10:FREE FERROMAGNETIC LAYER

Fig. 14

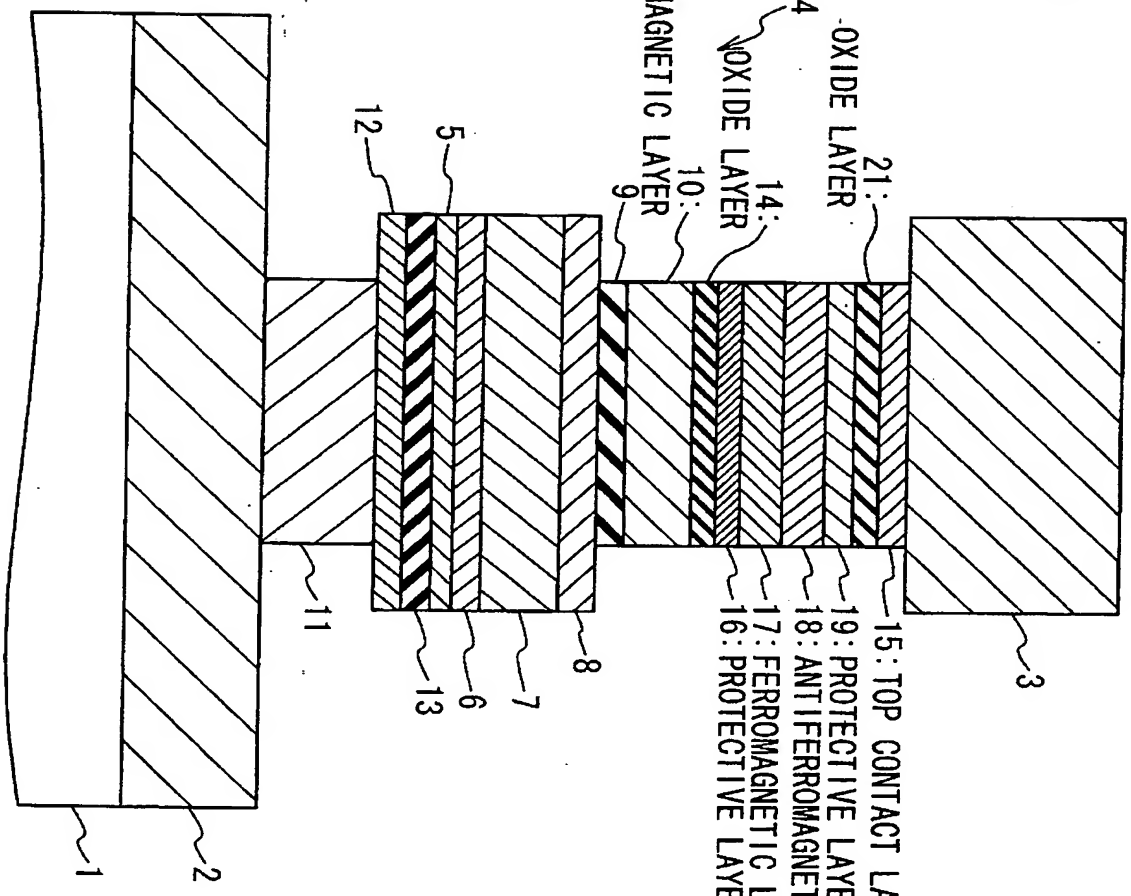

1
2
3
4
5
6
7
8
9
10: FREE FERROMAGNETIC LAYER
11
12
13
14: OXIDE LAYER
15: TOP CONTACT LAYER
16: PROTECTIVE LAYER
17: FERROMAGNETIC LAYER
18: ANTIFERROMAGNETIC LAYER
19: PROTECTIVE LAYER
20: MAGNETIC BIAS LAYER
21: OXIDE LAYER

Fig. 15

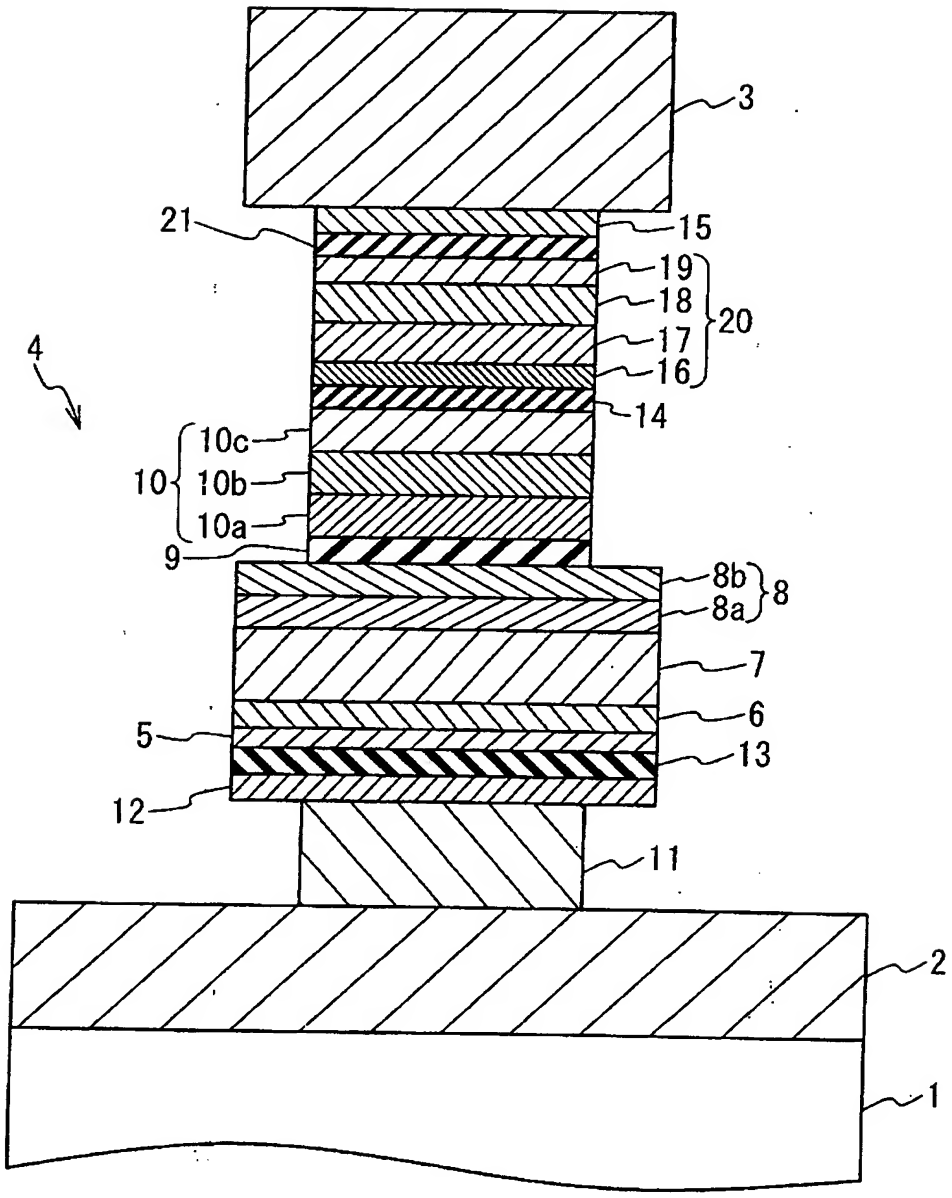


Fig. 16

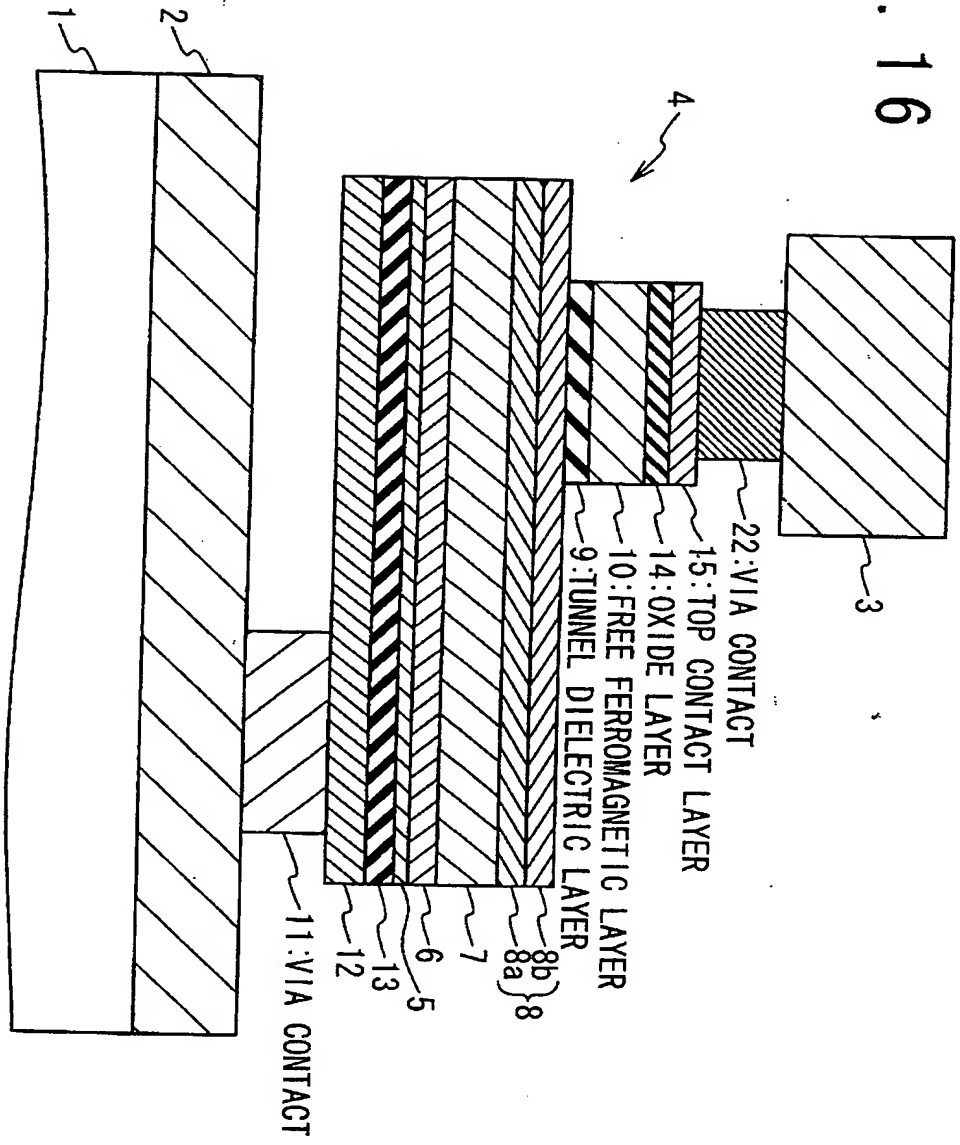

1
2
4
3
22:VIA CONTACT
15:TOP CONTACT LAYER
14:OXIDE LAYER
10:FREE FERROMAGNETIC LAYER
9:TUNNEL DIELECTRIC LAYER
8b
8a
8
7
6
5
13
12
11:VIA CONTACT

Fig. 17

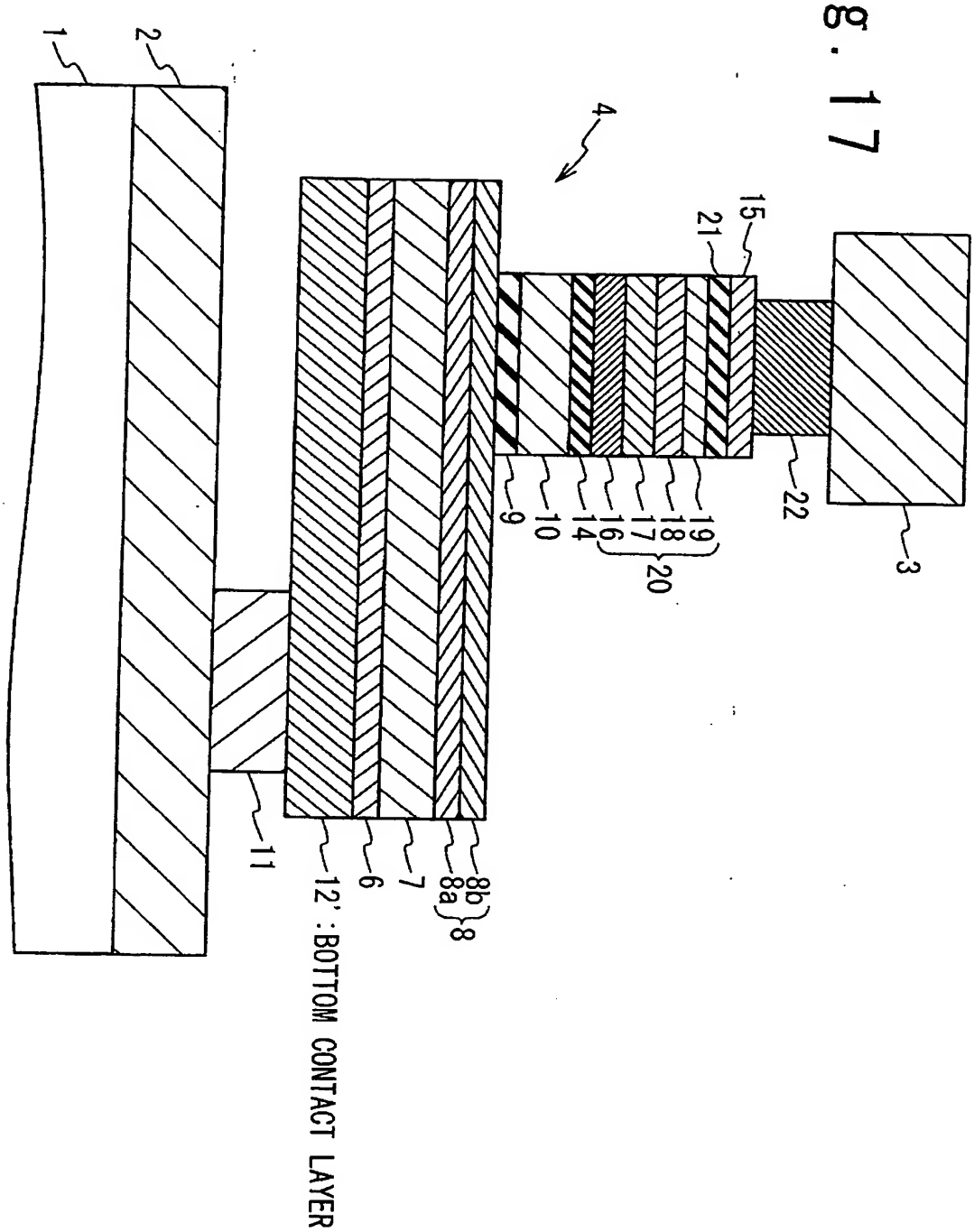

1
2
4
15
21
22
3
9
10
14
16
17
18
19
20
11
12'
6
7
8a
8b
8
12' : BOTTOM CONTACT LAYER

Fig. 18

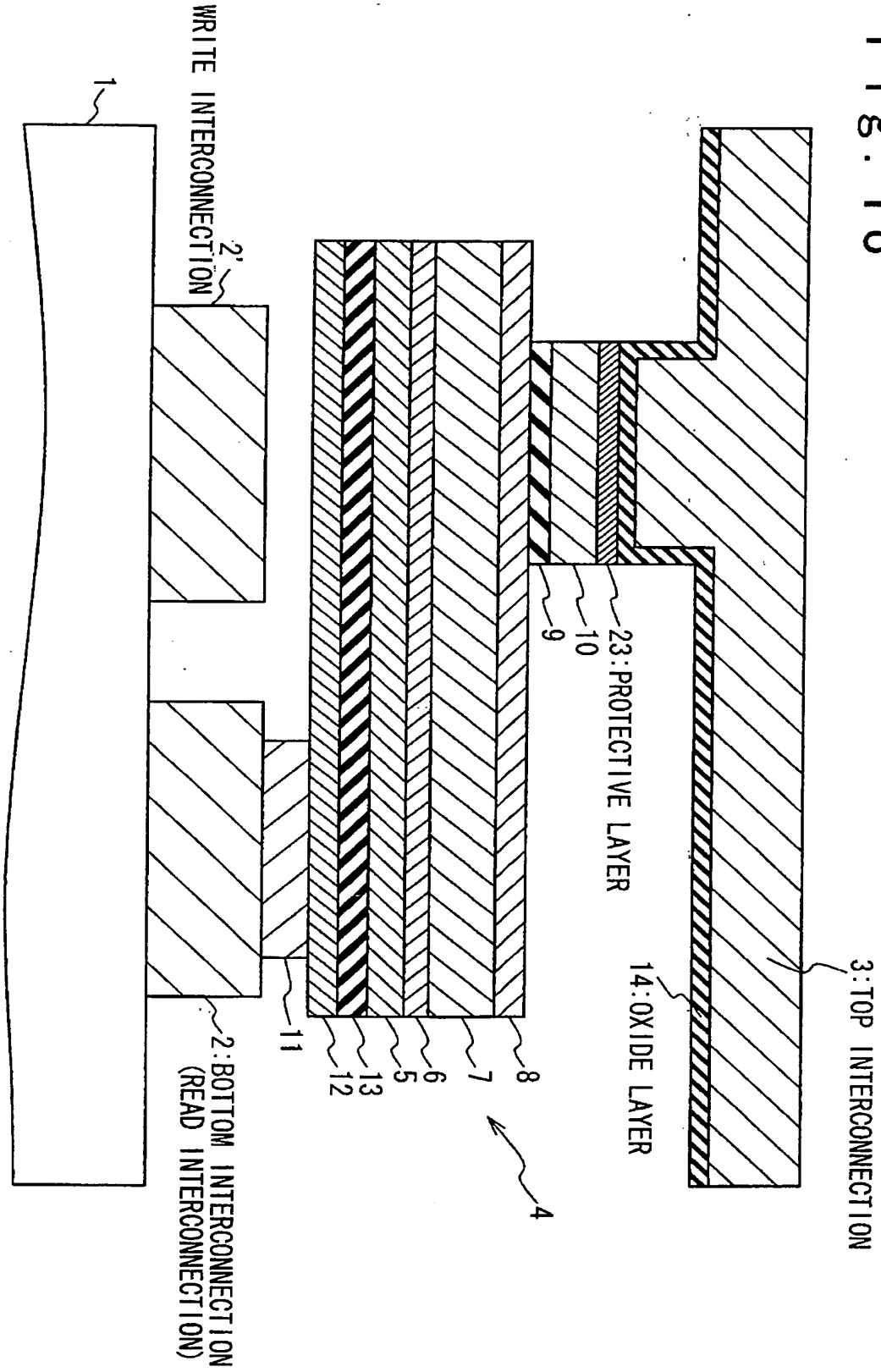

1
WRITE INTERCONNECTION
2'
3:TOP INTERCONNECTION
14:OXIDE LAYER
23:PROTECTIVE LAYER
9
10
11
2:BOTTOM INTERCONNECTION
(READ INTERCONNECTION)
12
13
5
6
7
8
4

Fig. 19

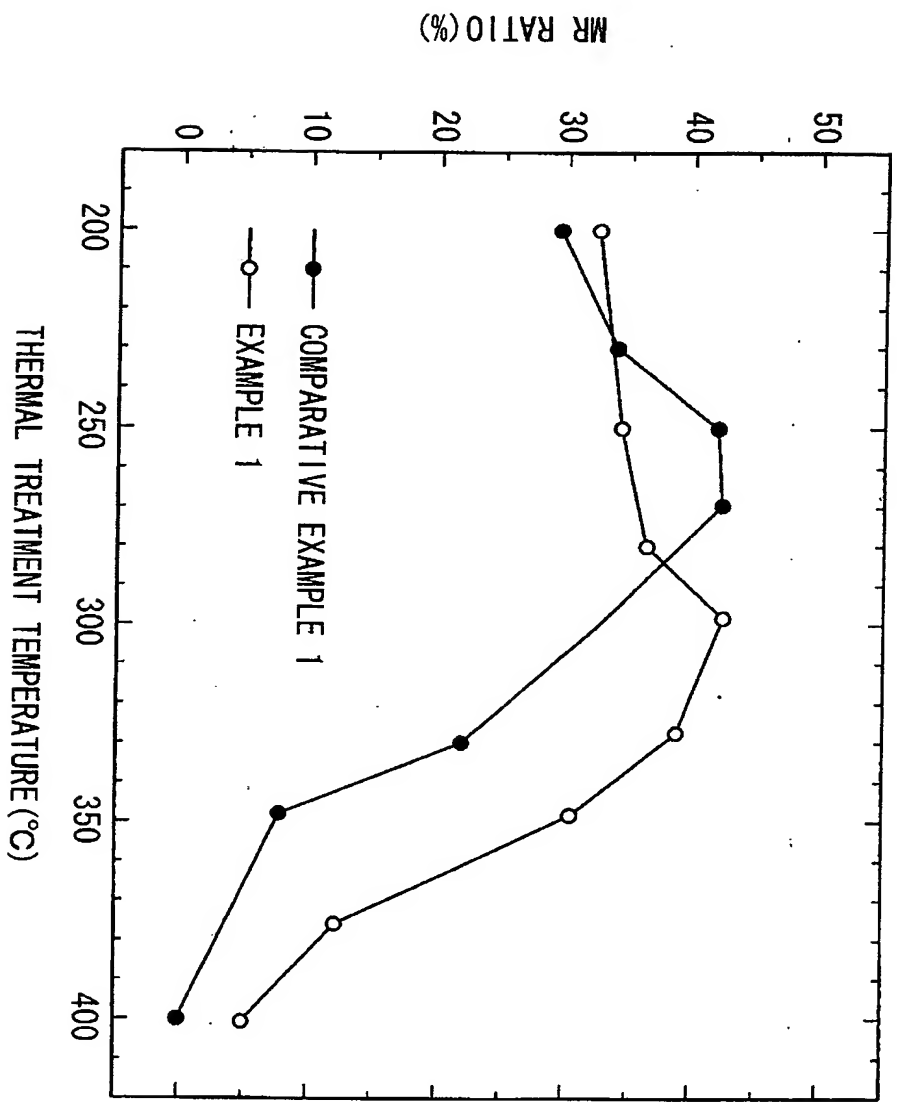

MR RATIO (%)
0
10
20
30
40
50
200
250
300
350
400
THERMAL TREATMENT TEMPERATURE (°C)
COMPARATIVE EXAMPLE 1
EXAMPLE 1

Fig. 20

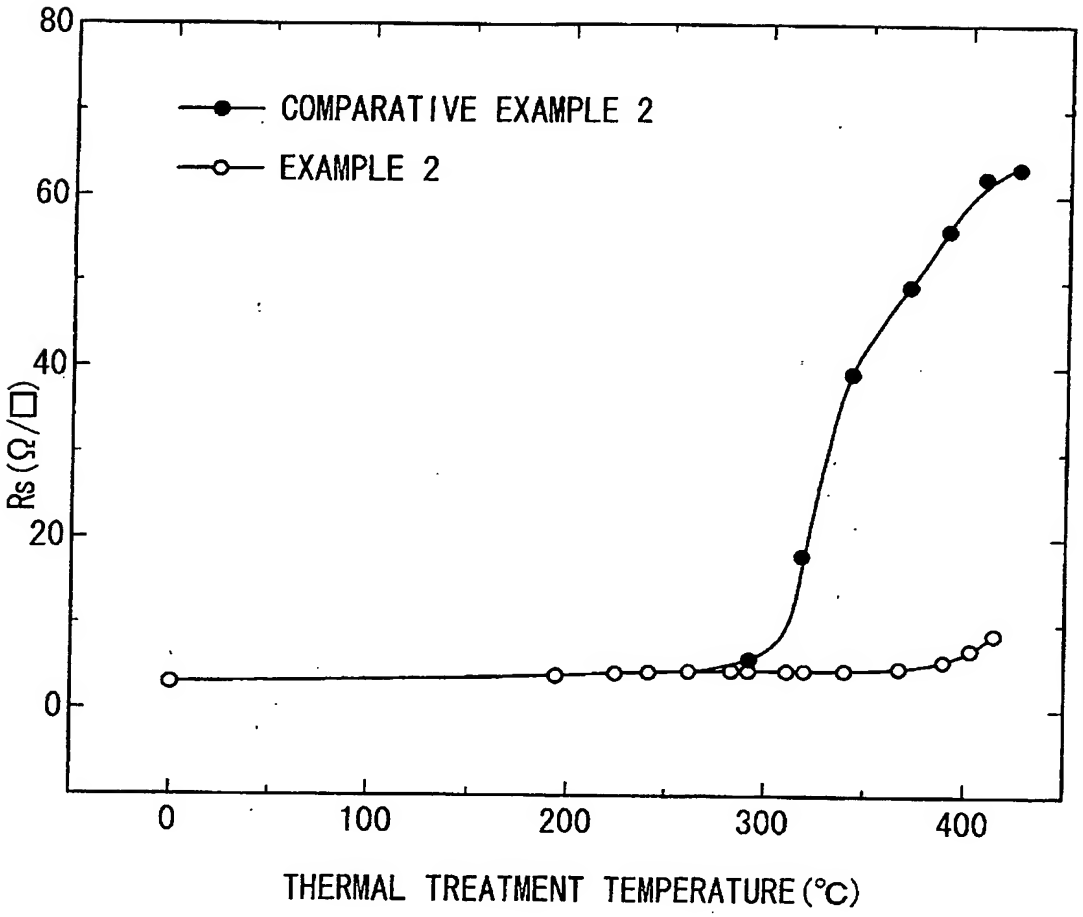

80
60
40
20
0
Rs (Ω/□)
COMPARATIVE EXAMPLE 2
EXAMPLE 2
0
100
200
300
400
THERMAL TREATMENT TEMPERATURE (°C)

Fig. 21

	LAYER CORRESPONDING TO OXIDE LAYER 13	THERMAL TREATMENT TEMPERATURE AND SHEET RESISTANCE AFTER THERMAL TREATMENT (Ω/□)			
		NO	300℃	350℃	400℃
COMPARATIVE EXAMPLE 2	NO	4.5	6.2	44.3	53.5
EXAMPLE 2	Al_2O_3 (1nm)	4.3	4.2	4	5.1
EXAMPLE 3	Mgo (1nm)	4.7	4.2	4.5	5.1

Fig. 22

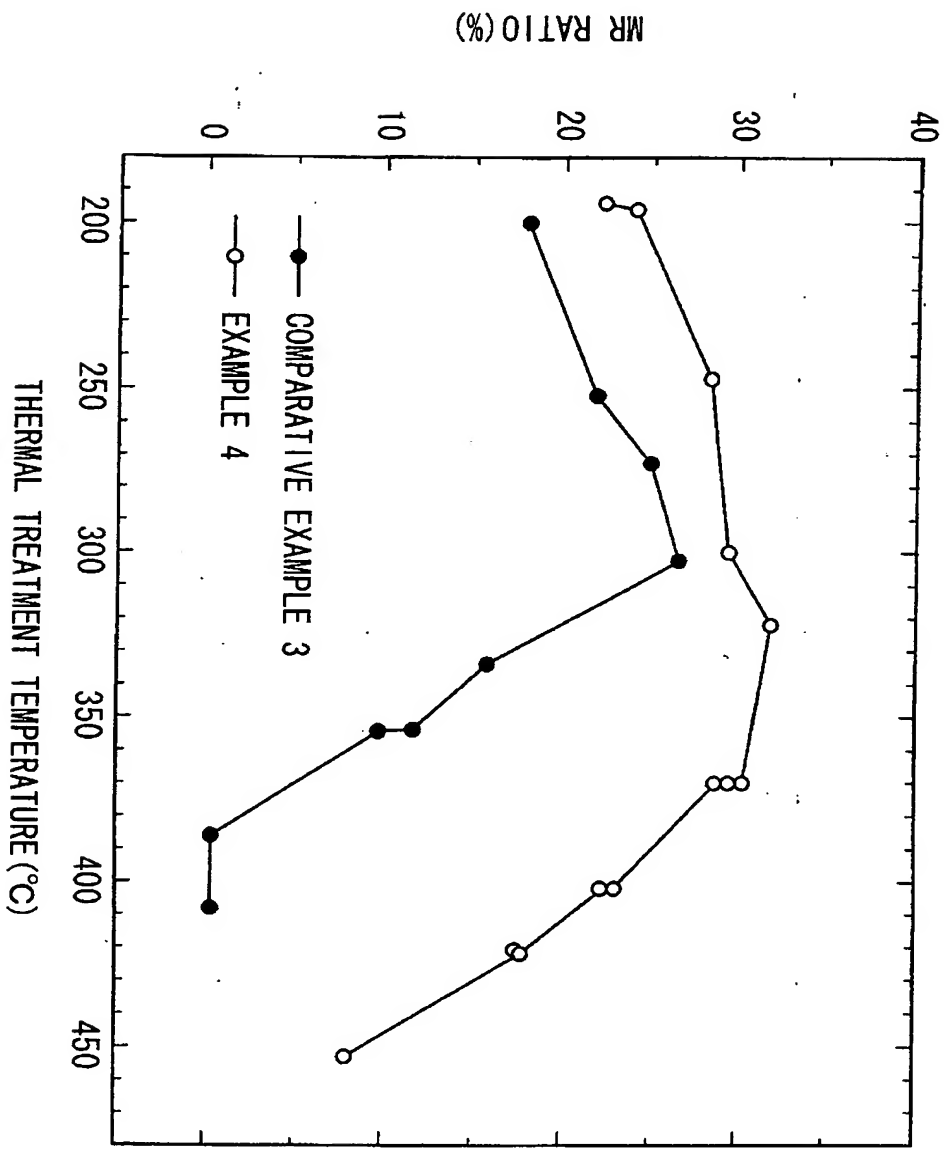

MR RATIO (%)
0
10
20
30
40
200
250
300
350
400
450
THERMAL TREATMENT TEMPERATURE (°C)
COMPARATIVE EXAMPLE 3
EXAMPLE 4

Fig. 23

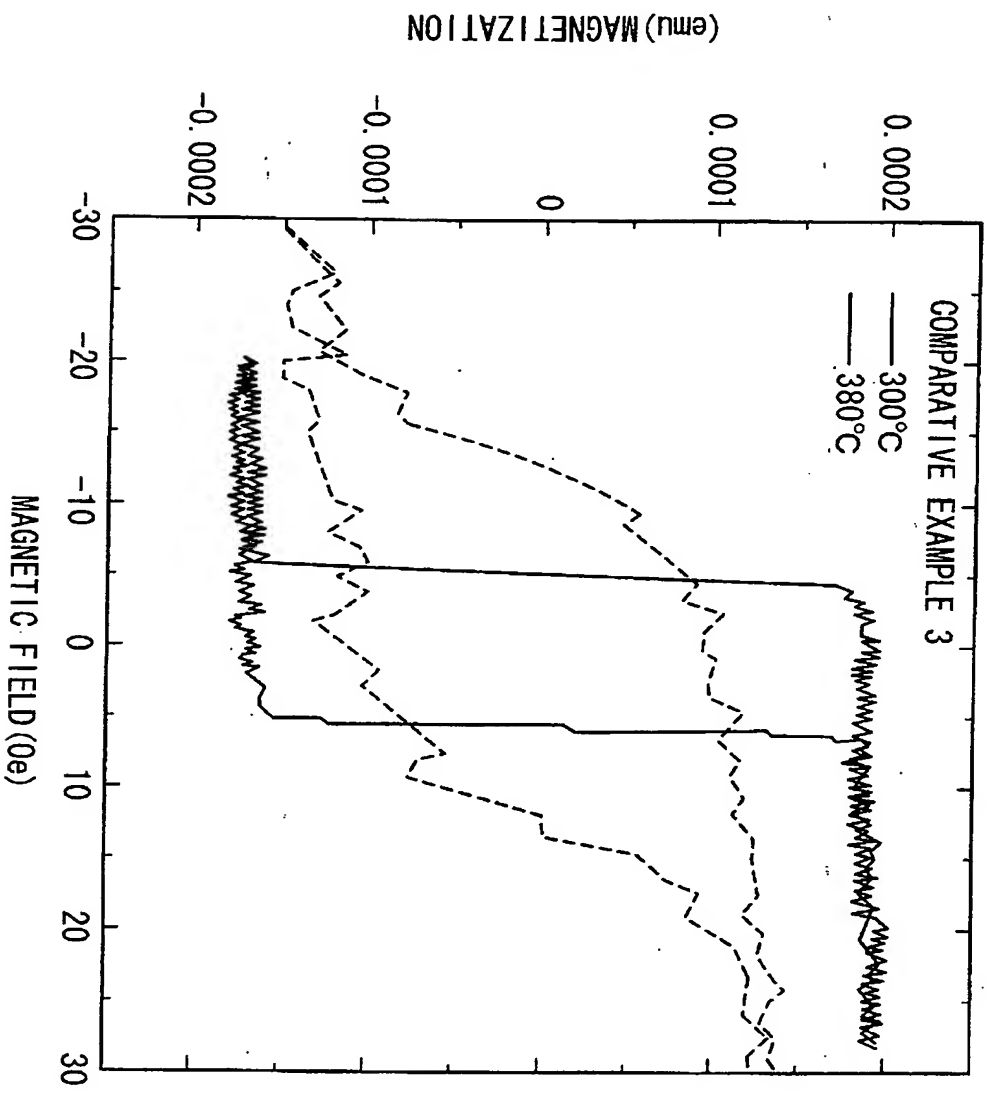

COMPARATIVE EXAMPLE 3
300°C
380°C
MAGNETIZATION (emu)
0.0002
0.0001
0
-0.0001
-0.0002
MAGNETIC FIELD (Oe)
-30
-20
-10
0
10
20
30

Fig. 24

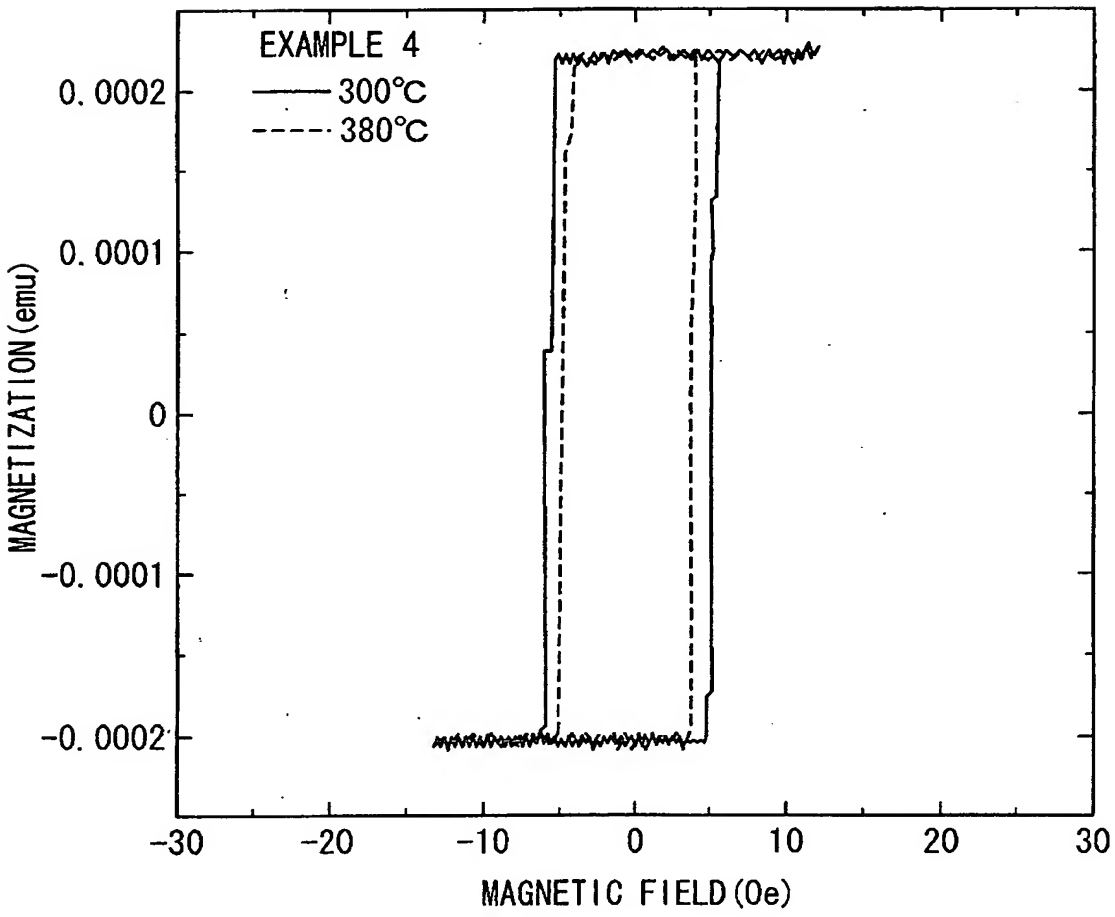

EXAMPLE 4
300°C
380°C
0.0002
0.0001
0
-0.0001
-0.0002
MAGNETIZATION(emu)
-30
-20
-10
0
10
20
30
MAGNETIC FIELD(Oe)

Fig. 25

	LAYER CORRESPONDING TO OXIDE LAYER 14	THERMAL TREATMENT TEMPERATURE AND SATURATED MAGNETIZATION AFTER THERMAL TREATMENT (emu/cc)				
		NO	200℃	300℃	380℃	400℃
COMPARATIVE EXAMPLE 4	NO	744	736	692	455	35
COMPARATIVE EXAMPLE 5	NO	748	744	724	633	610
EXAMPLE 5	Al_2O_3 (1nm)	783	787	775	771	772
EXAMPLE 6	Mgo (1nm)	775	771	775	774	773

Fig. 26

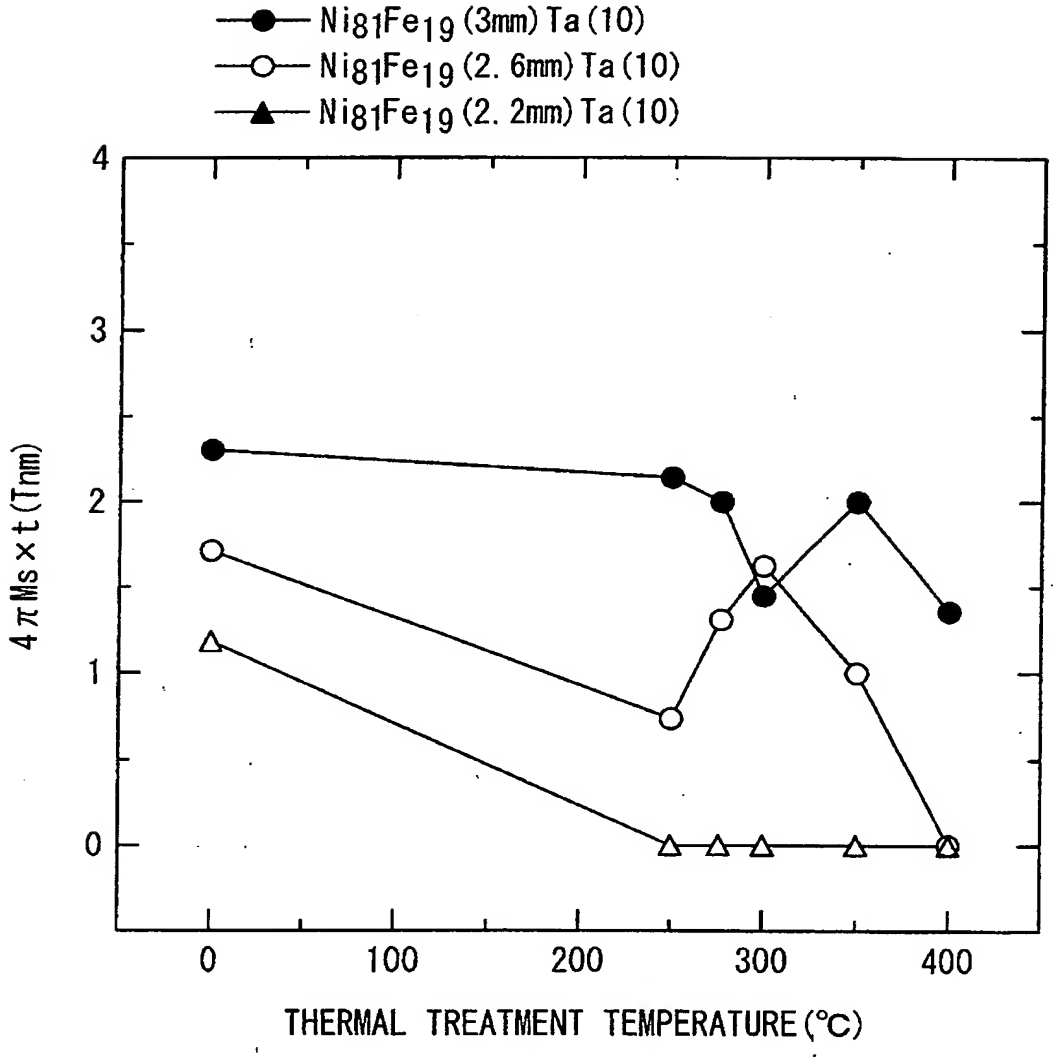

Ni81Fe19 (3mm) Ta (10)
Ni81Fe19 (2. 6mm) Ta (10)
Ni81Fe19 (2. 2mm) Ta (10)
4πMs×t (Tnm)
0
1
2
3
4
0
100
200
300
400
THERMAL TREATMENT TEMPERATURE (°C)

Fig. 27

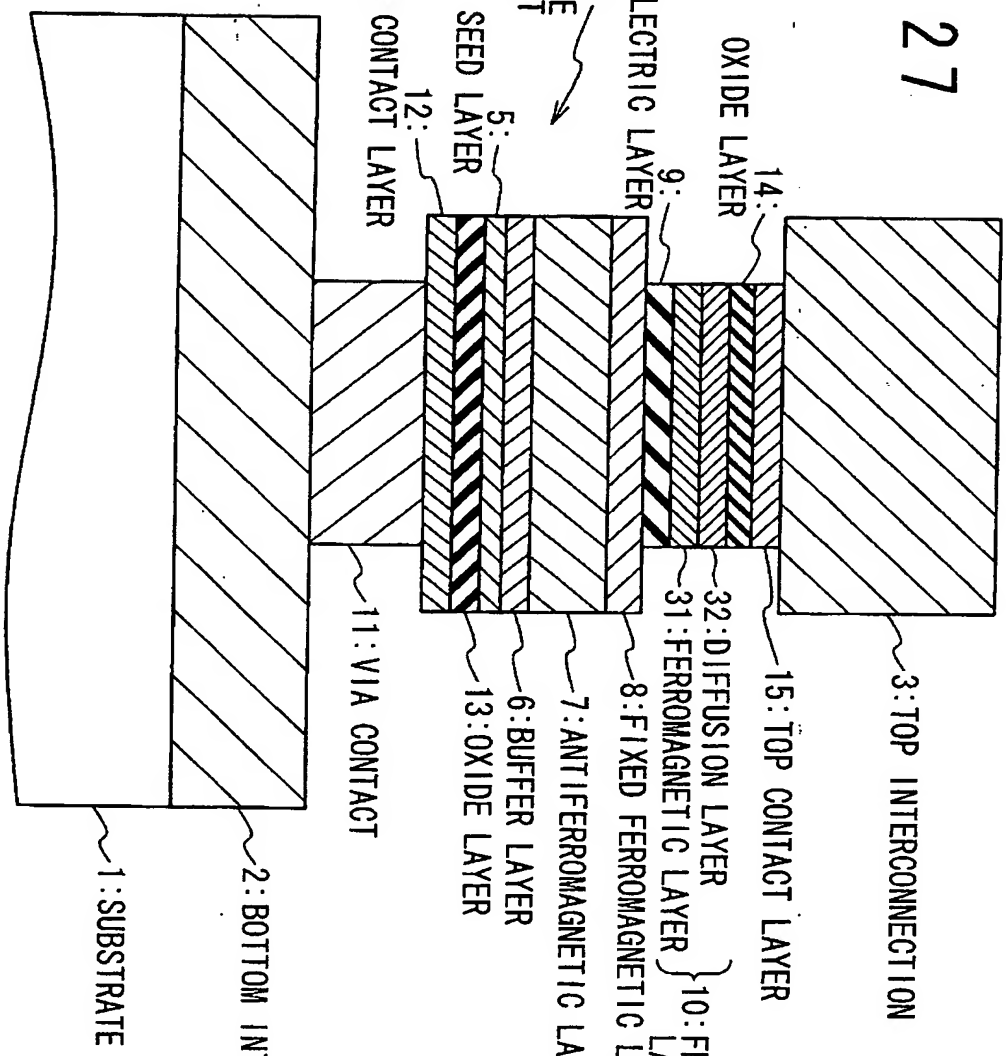

3: TOP INTERCONNECTION
15: TOP CONTACT LAYER
14: OXIDE LAYER
32: DIFFUSION LAYER
31: FERROMAGNETIC LAYER
10: FREE FERROMAGNETIC LAYER
9: TUNNEL DIELECTRIC LAYER
8: FIXED FERROMAGNETIC LAYER
4: MAGNETORESISTANCE ELEMENT
7: ANTIFERROMAGNETIC LAYER
5: SEED LAYER
6: BUFFER LAYER
12: BOTTOM CONTACT LAYER
13: OXIDE LAYER
11: VIA CONTACT
2: BOTTOM INTERCONNECTION
1: SUBSTRATE

Fig. 28

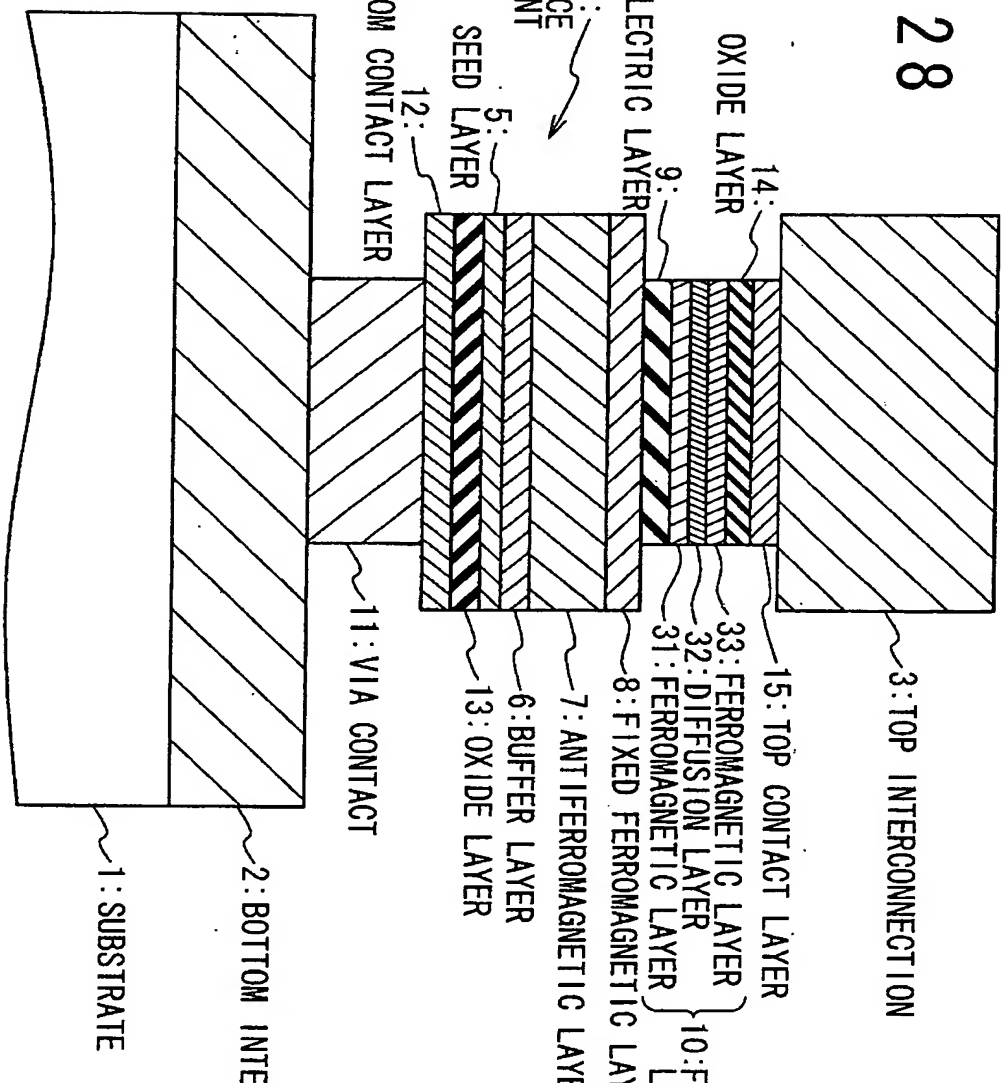

3: TOP INTERCONNECTION
15: TOP CONTACT LAYER
33: FERROMAGNETIC LAYER
32: DIFFUSION LAYER
31: FERROMAGNETIC LAYER
10: FREE FERROMAGNETIC LAYER
8: FIXED FERROMAGNETIC LAYER
7: ANTIFERROMAGNETIC LAYER
6: BUFFER LAYER
13: OXIDE LAYER
11: VIA CONTACT
2: BOTTOM INTERCONNECTION
1: SUBSTRATE
14: OXIDE LAYER
9: TUNNEL DIELECTRIC LAYER
4: MAGNETORESISTANCE ELEMENT
5: SEED LAYER
12: BOTTOM CONTACT LAYER

Fig. 29

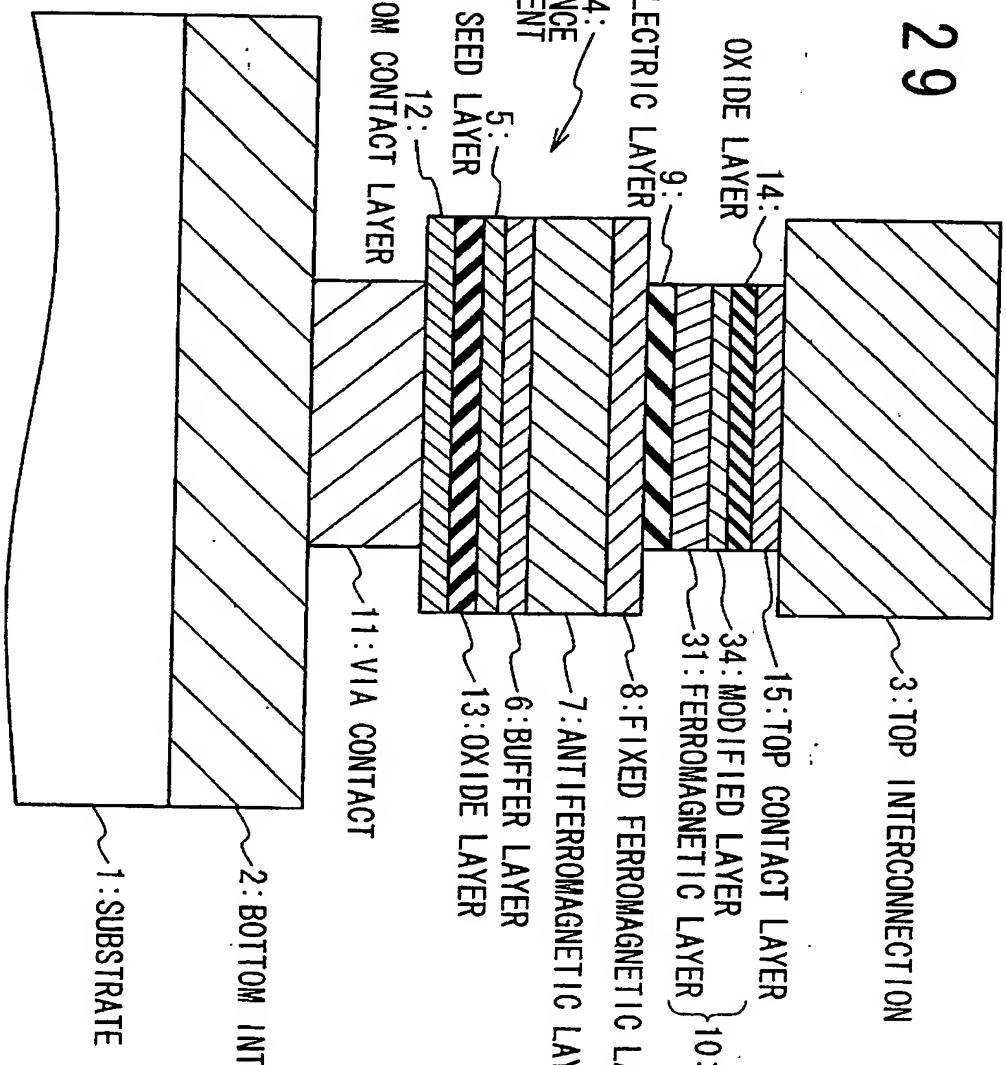

3:TOP INTERCONNECTION
15:TOP CONTACT LAYER
34:MODIFIED LAYER
31:FERROMAGNETIC LAYER
10:FREE FERROMAGNETIC LAYER
8:FIXED FERROMAGNETIC LAYER
7:ANTIFERROMAGNETIC LAYER
6:BUFFER LAYER
13:OXIDE LAYER
11:VIA CONTACT
2:BOTTOM INTERCONNECTION
1:SUBSTRATE
14: OXIDE LAYER
9: TUNNEL DIELECTRIC LAYER
4: MAGNETORESISTANCE ELEMENT
5: SEED LAYER
12: BOTTOM CONTACT LAYER

Fig. 30

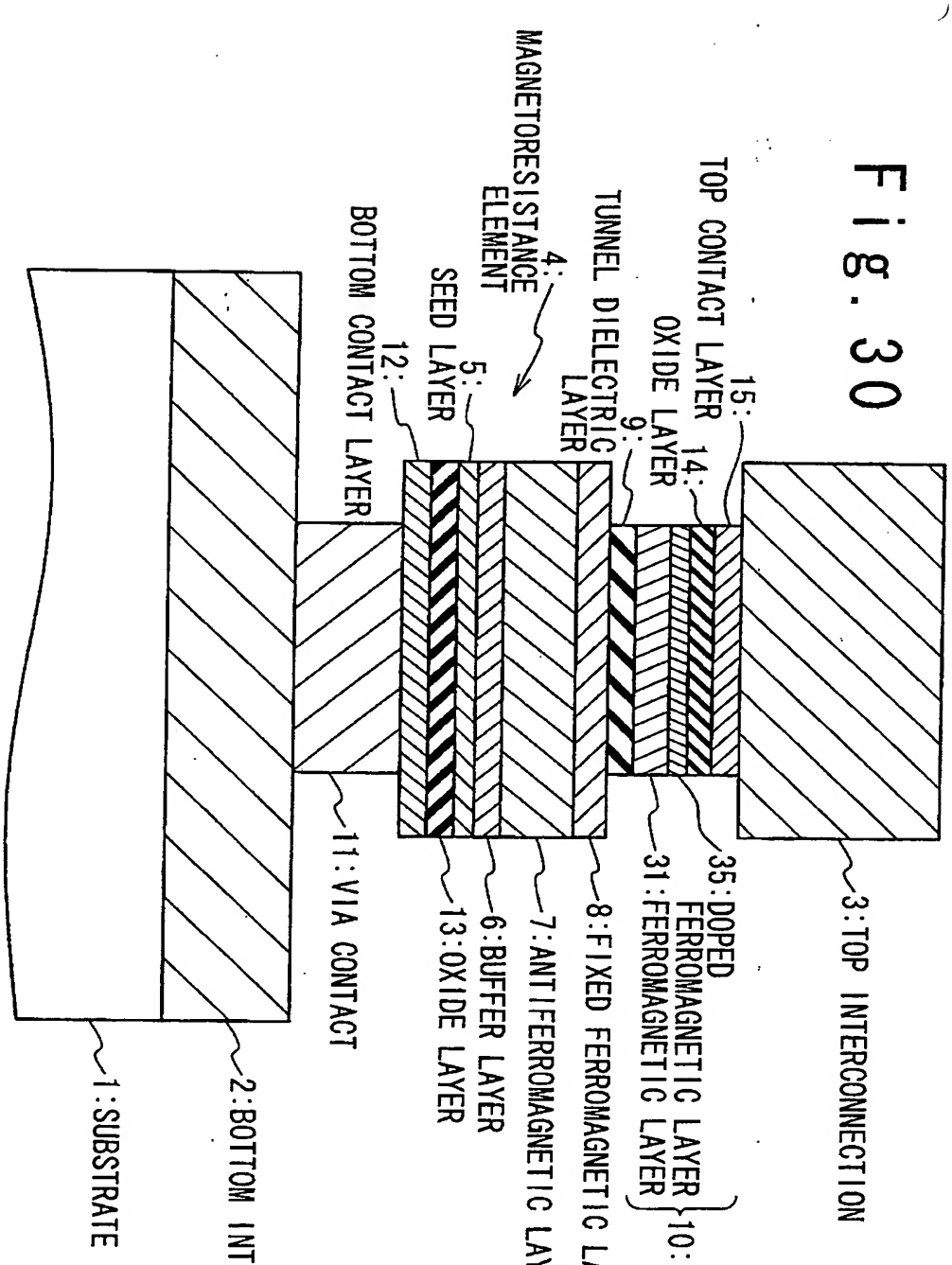

1:SUBSTRATE
2:BOTTOM INTERCONNECTION
11:VIA CONTACT
BOTTOM CONTACT LAYER
12:
SEED LAYER
5:
4:
MAGNETORESISTANCE ELEMENT
13:OXIDE LAYER
6:BUFFER LAYER
7:ANTIFERROMAGNETIC LAYER
8:FIXED FERROMAGNETIC LAYER
TUNNEL DIELECTRIC LAYER
9:
31:FERROMAGNETIC LAYER
35:DOPED FERROMAGNETIC LAYER
10:FREE FERROMAGNETIC LAYER
OXIDE LAYER
14:
TOP CONTACT LAYER
15:
3:TOP INTERCONNECTION

Fig. 31

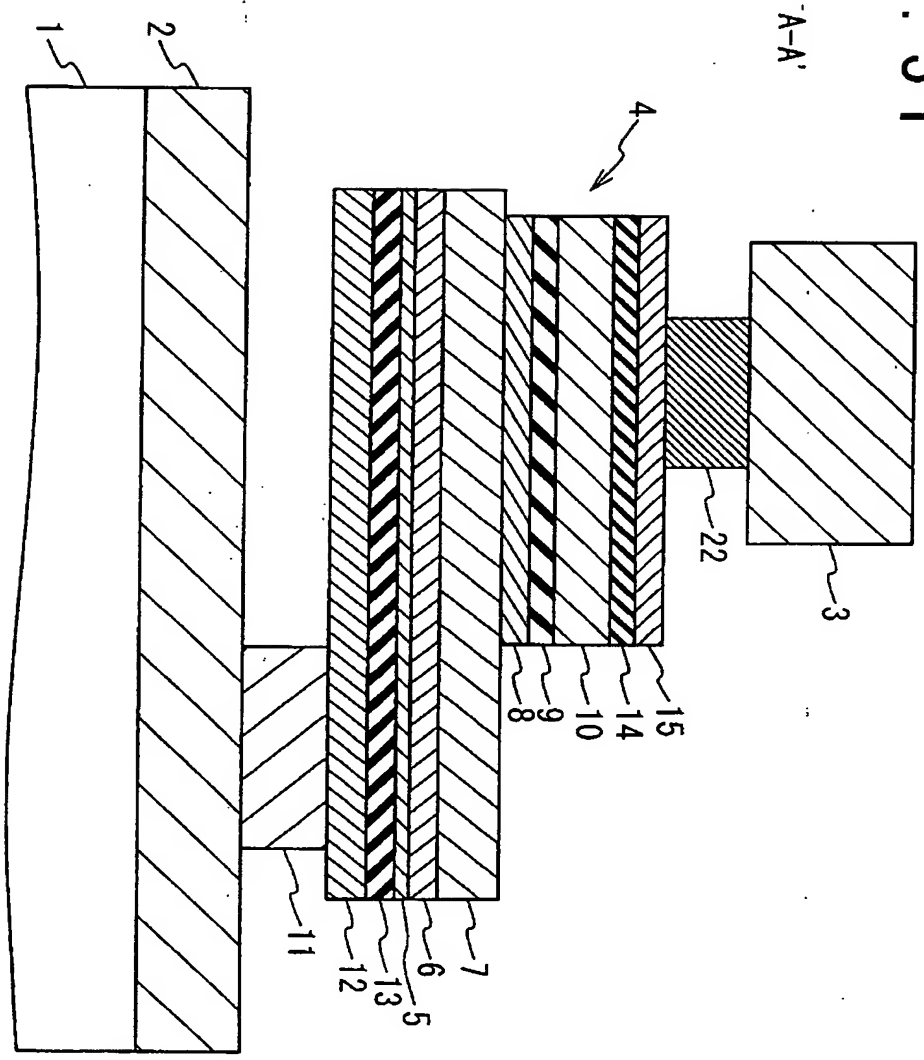


Fig. 32

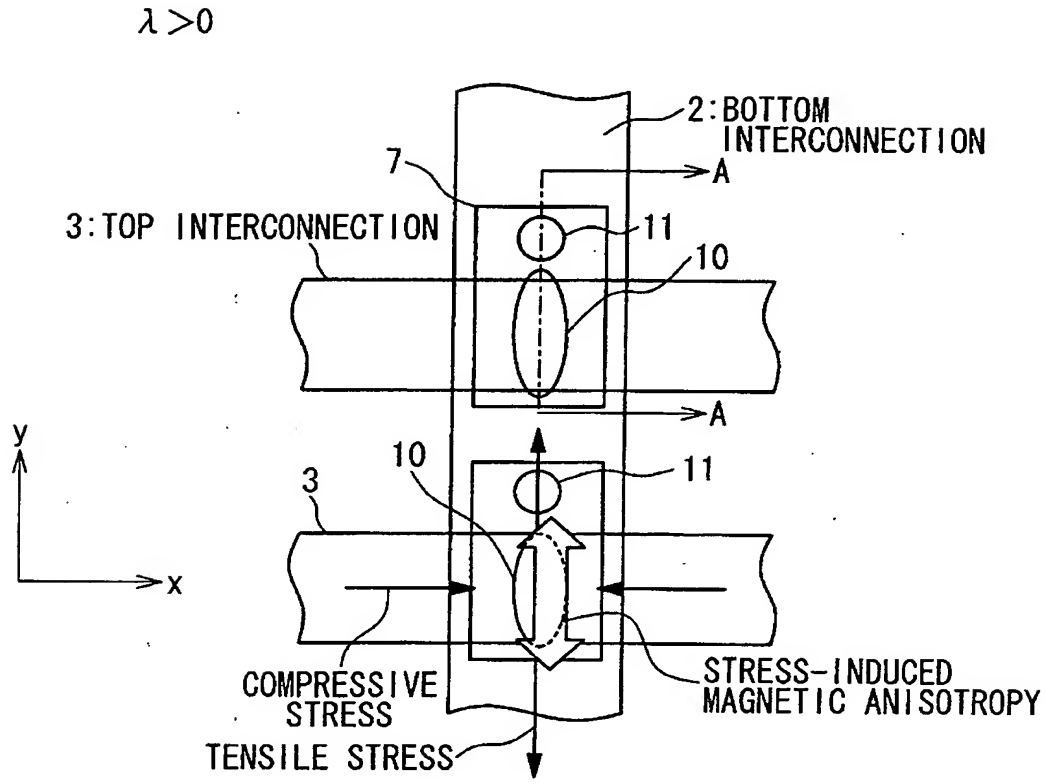
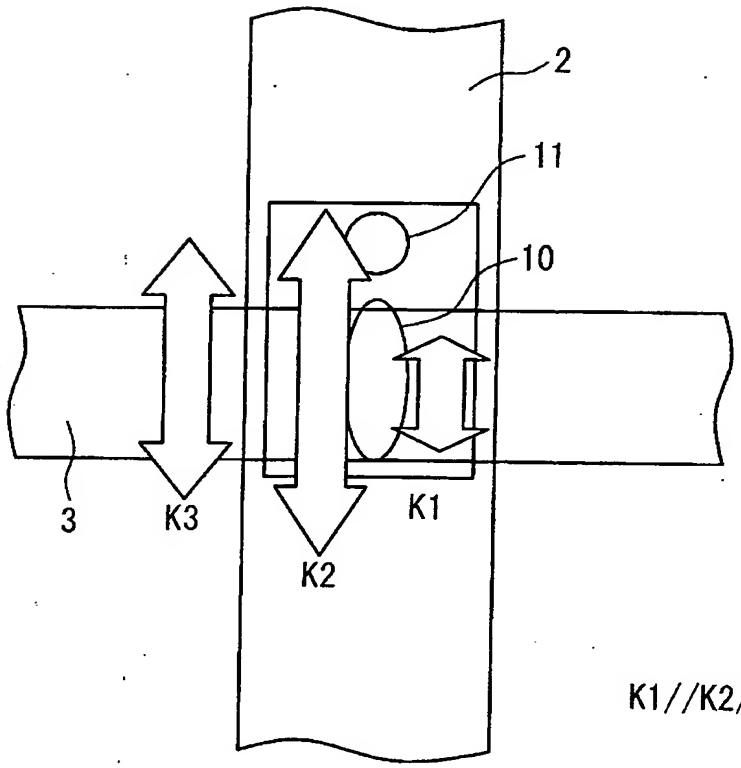

λ>0
2:BOTTOM INTERCONNECTION
7
A
3:TOP INTERCONNECTION
11
10
A
y
10
11
3
x
COMPRESSIVE STRESS
STRESS-INDUCED MAGNETIC ANISOTROPY
TENSILE STRESS

Fig. 33



K1//K2//K3

Fig. 34

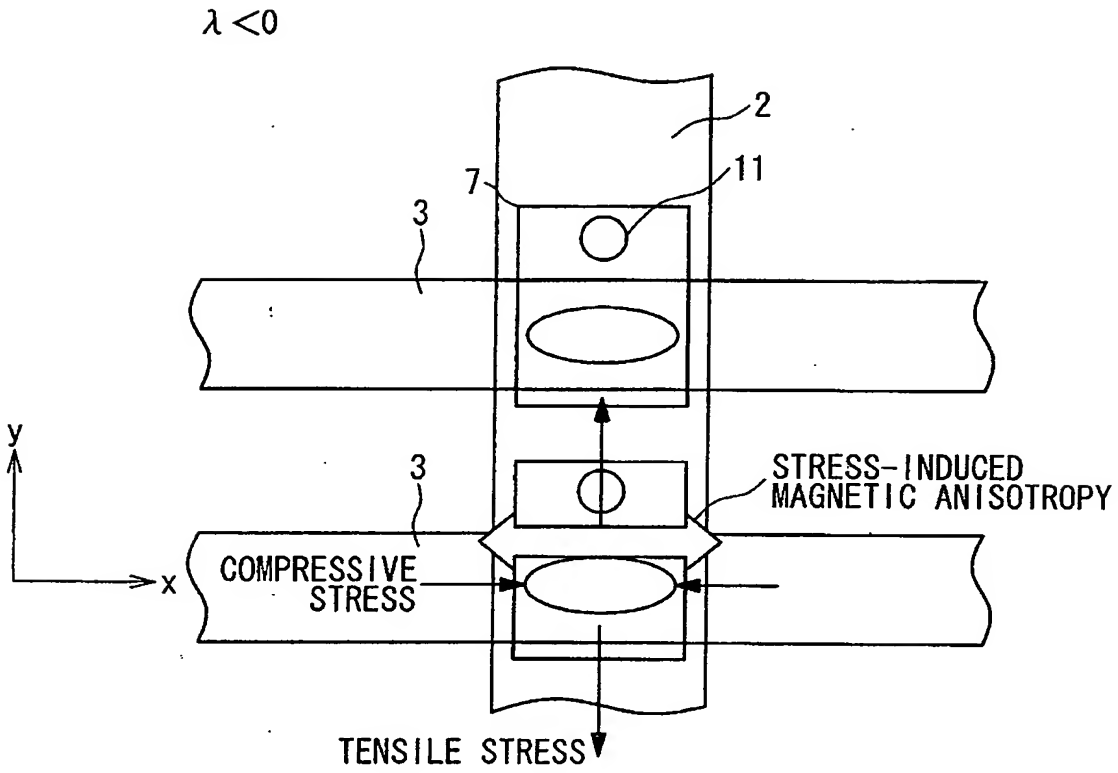

λ<0
2
7
11
3
3
y
x
STRESS-INDUCED
MAGNETIC ANISOTROPY
COMPRESSIVE
STRESS
TENSILE STRESS

Fig. 35

$\lambda > 0$

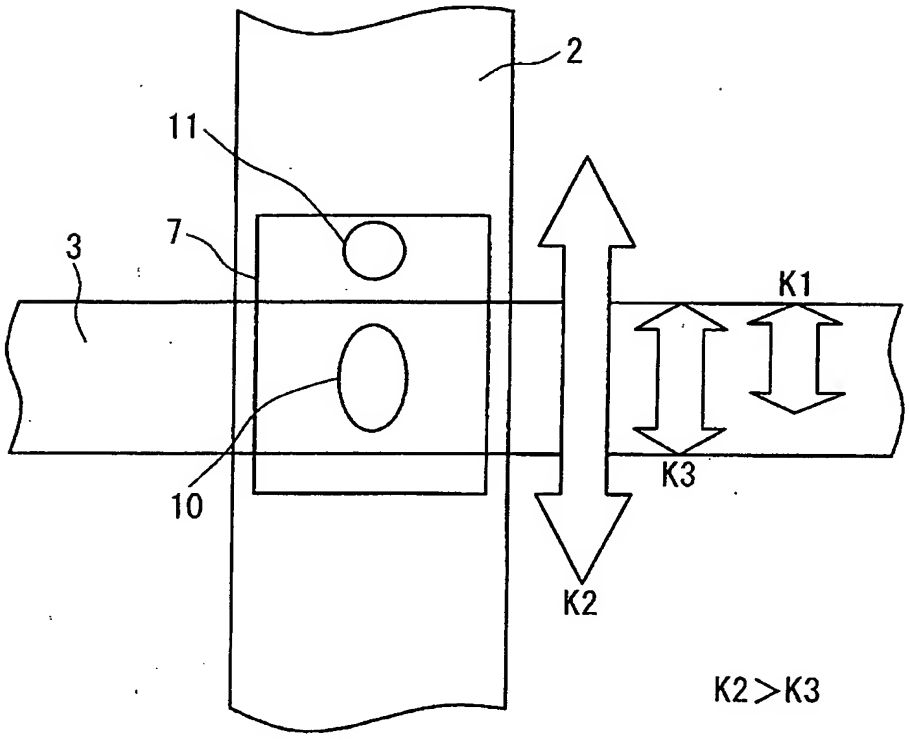


Fig. 36

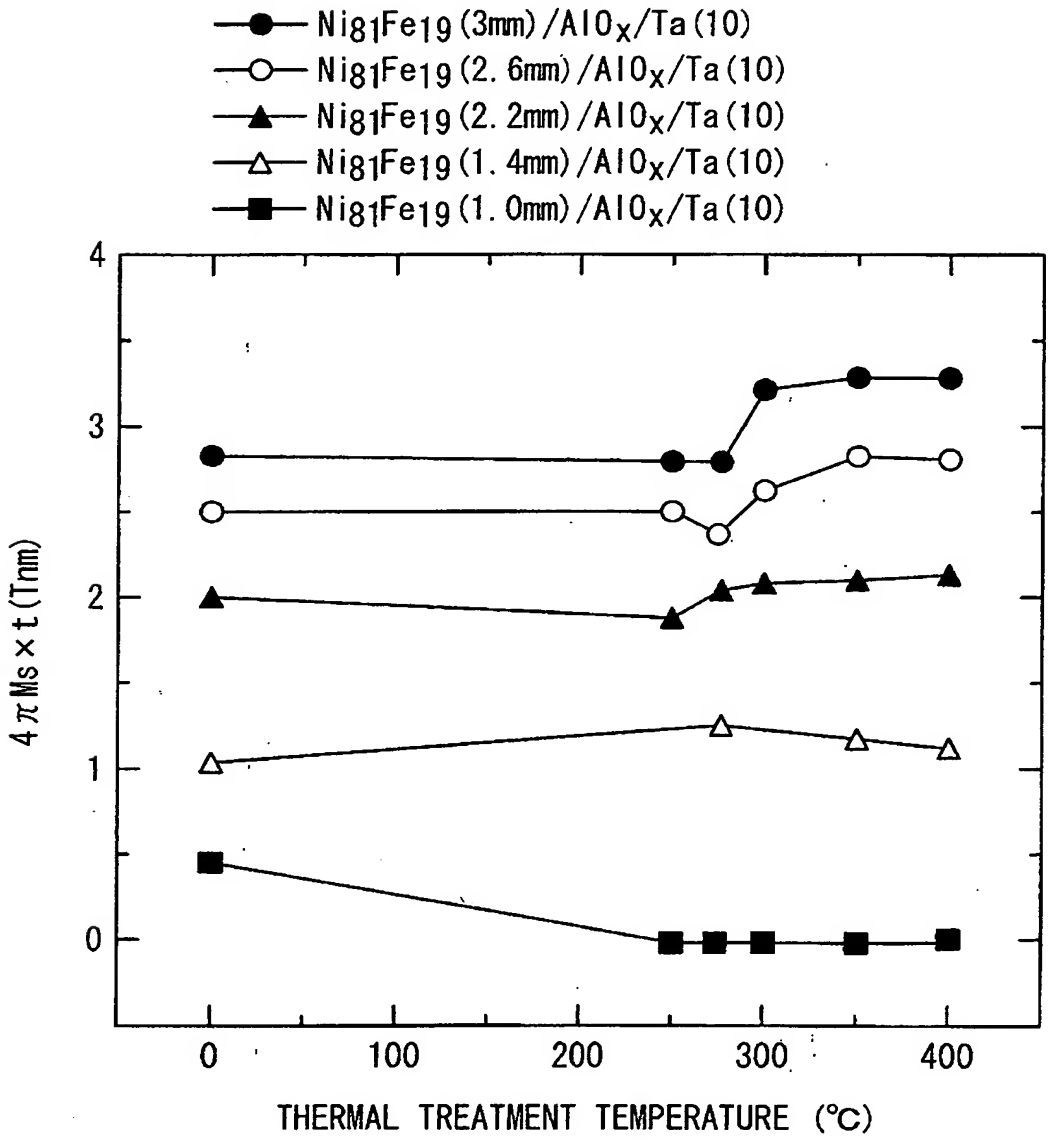

Ni81Fe19 (3nm) /AlOx/Ta (10)
Ni81Fe19 (2. 6nm) /AlOx/Ta (10)
Ni81Fe19 (2. 2nm) /AlOx/Ta (10)
Ni81Fe19 (1. 4nm) /AlOx/Ta (10)
Ni81Fe19 (1. 0nm) /AlOx/Ta (10)
4πMs×t (Tnm)
0
1
2
3
4
0
100
200
300
400
THERMAL TREATMENT TEMPERATURE (°C)

Fig. 37

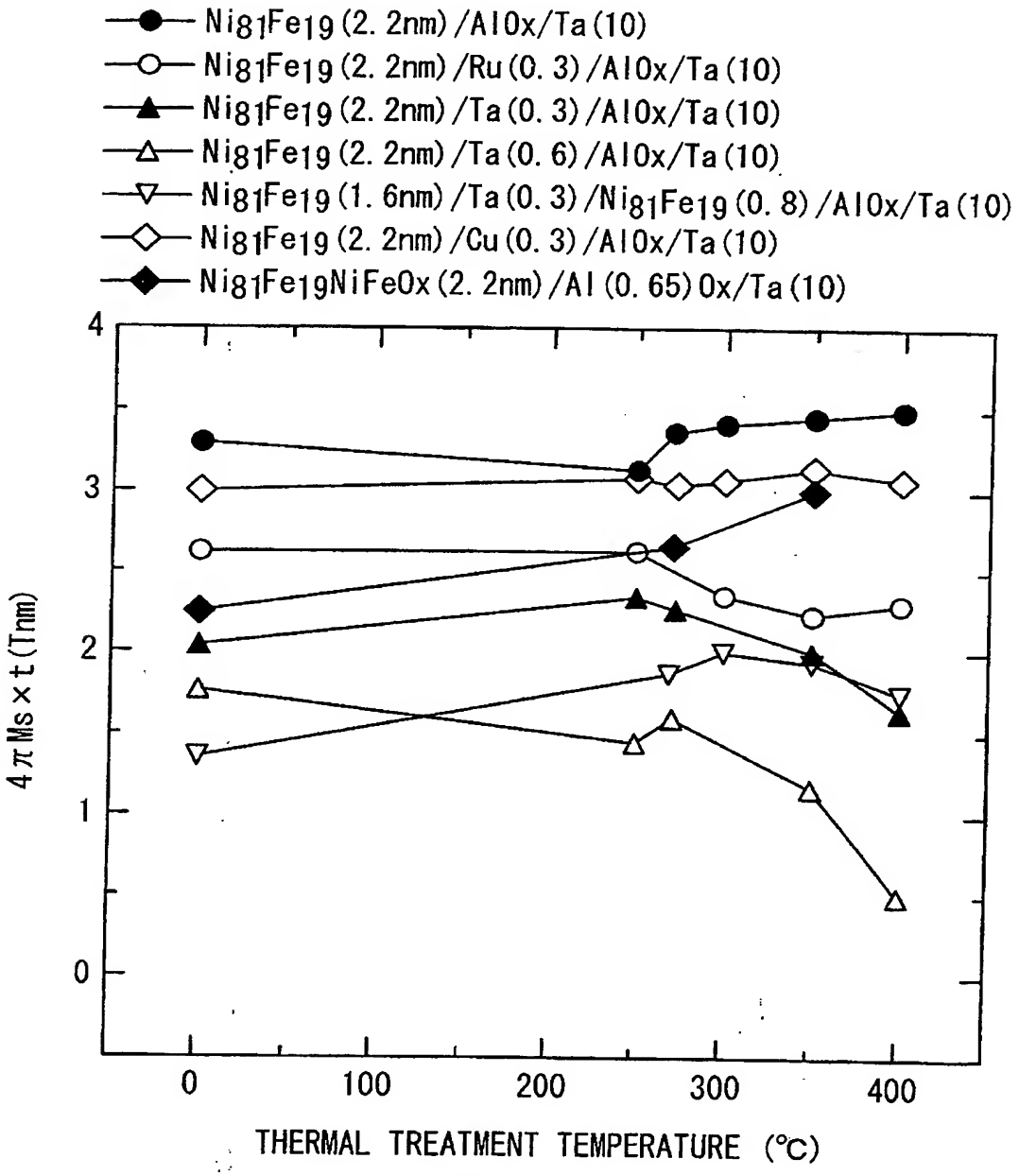

Ni81Fe19 (2. 2nm) /AlOx/Ta (10)
Ni81Fe19 (2. 2nm) /Ru (0. 3) /AlOx/Ta (10)
Ni81Fe19 (2. 2nm) /Ta (0. 3) /AlOx/Ta (10)
Ni81Fe19 (2. 2nm) /Ta (0. 6) /AlOx/Ta (10)
Ni81Fe19 (1. 6nm) /Ta (0. 3) /Ni81Fe19 (0. 8) /AlOx/Ta (10)
Ni81Fe19 (2. 2nm) /Cu (0. 3) /AlOx/Ta (10)
Ni81Fe19NiFeOx (2. 2nm) /Al (0. 65) Ox/Ta (10)
4πMs × t (Tnm)
0
1
2
3
4
0
100
200
300
400
THERMAL TREATMENT TEMPERATURE (°C)

Fig. 38

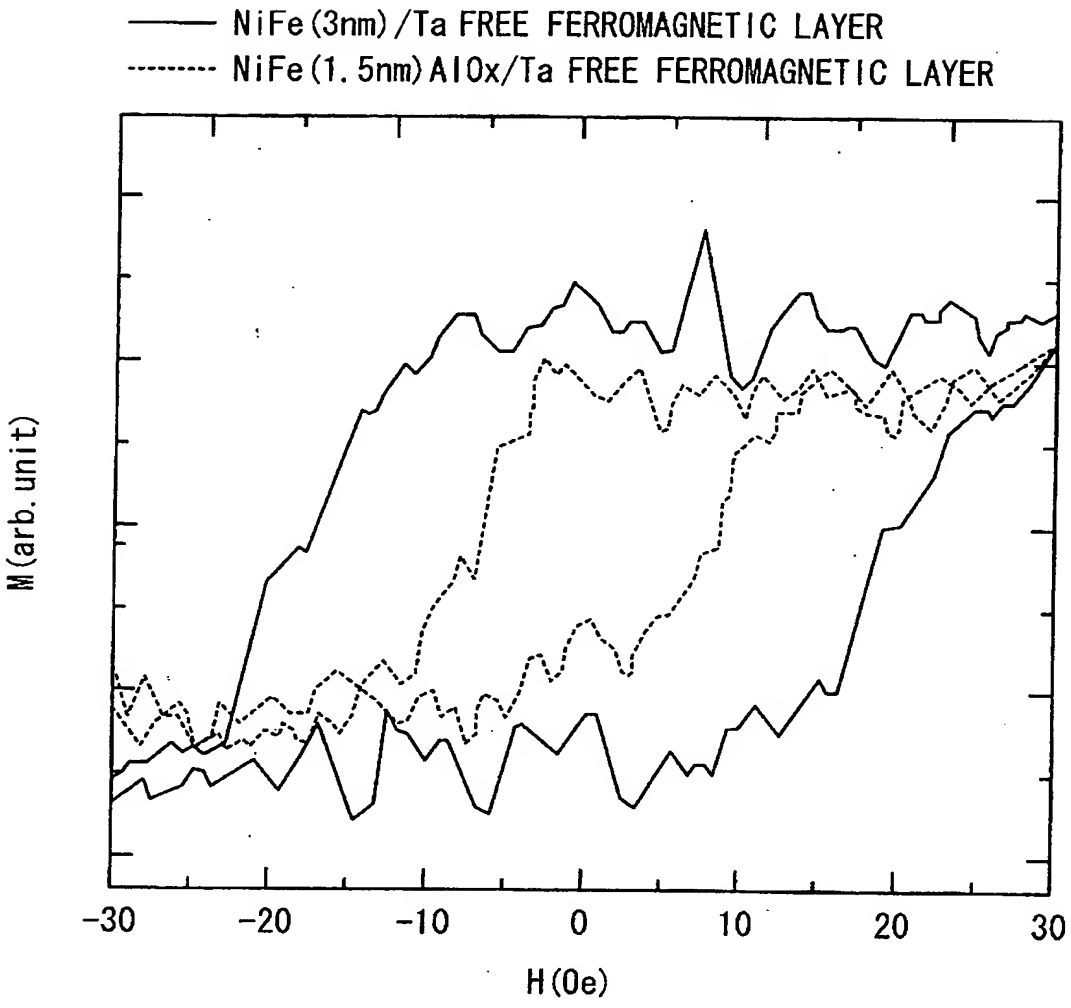

NiFe(3nm)/Ta FREE FERROMAGNETIC LAYER
NiFe(1.5nm)AlOx/Ta FREE FERROMAGNETIC LAYER
M(arb.unit)
-30
-20
-10
0
10
20
30
H(Oe)

Fig. 39A

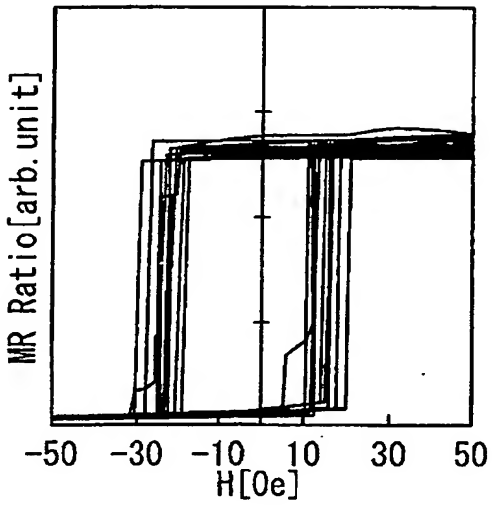


Fig. 39B

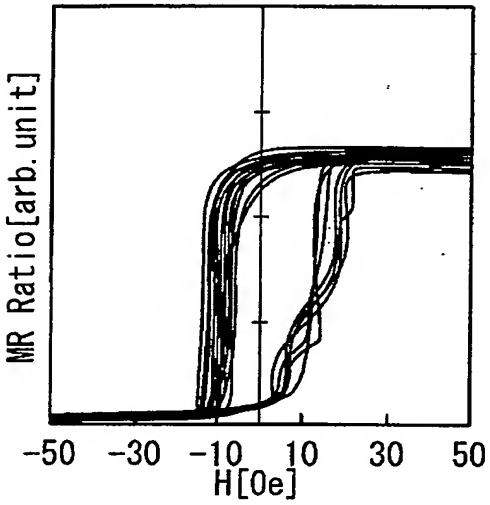


Fig. 39C

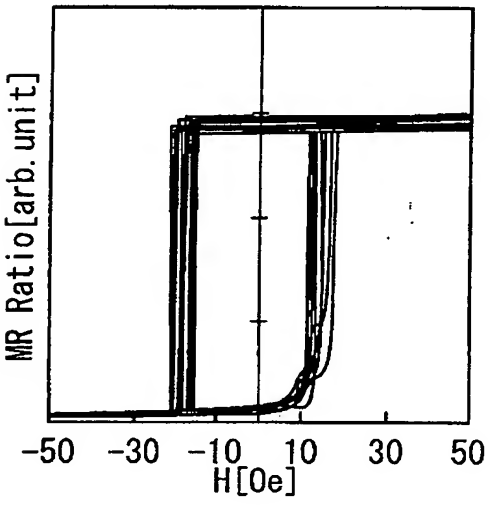


Fig. 40